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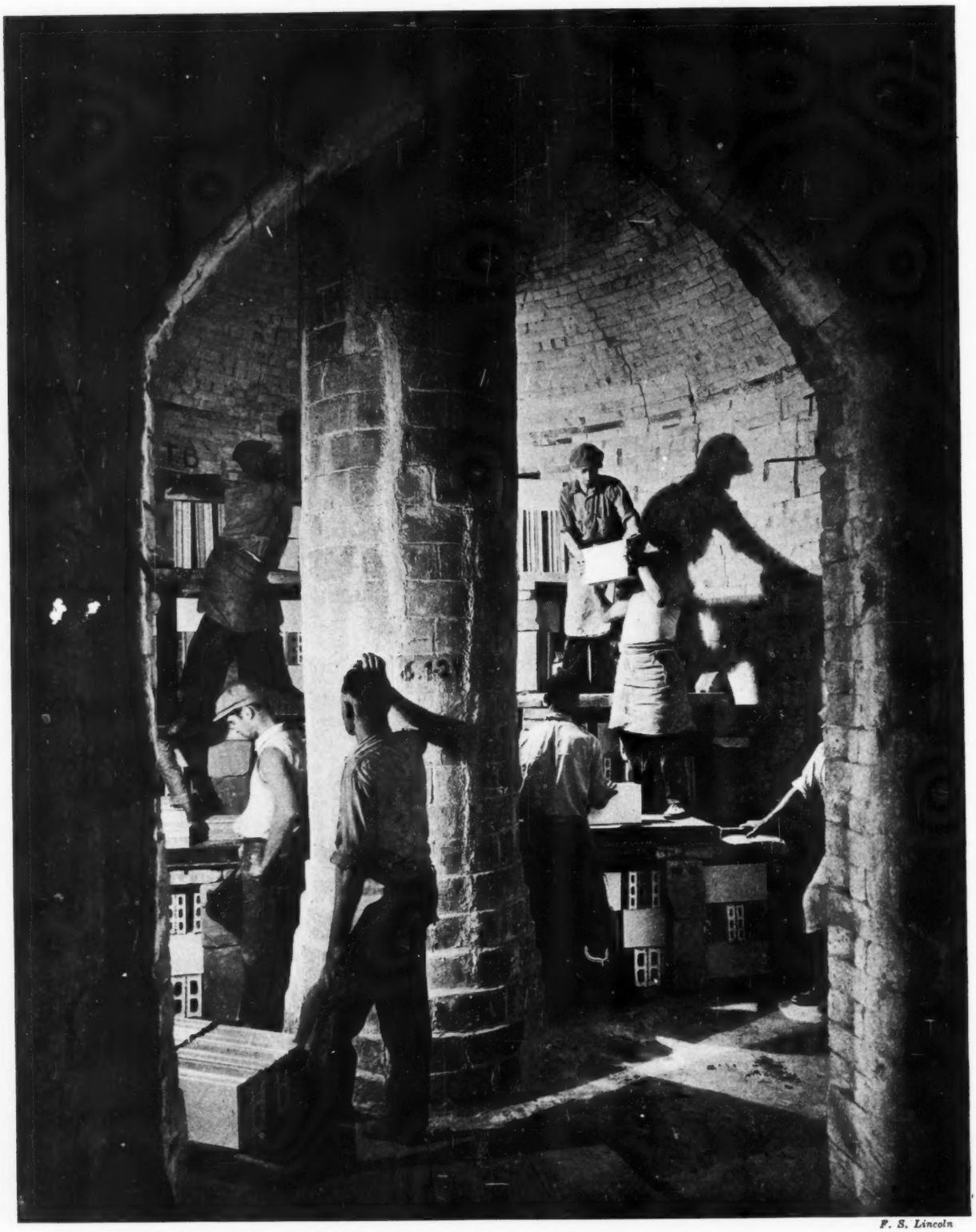

F. S. Lincoln

Charging the Kiln

Lessons *of* Unemployment

A Report to the Professional Engineers' Committee on Unemployment[1]

By W. A. SHOUDY[2]

IT IS my privilege to offer the following report as General Chairman of the Professional Engineers' Committee on Unemployment for the period beginning April 3, 1933. On that date my predecessor, Rear-Admiral Frederic R. Harris, Am.Soc.C.E., found it necessary to resign because of his appointment by the Mayor to the Emergency Work and Relief Administration of the City of New York. His report has been in your hands for some months. My work has consisted in following out the program which he left completely organized. If any changes have been made, they have been due to a different interpretation rather than an attempt to alter this excellent program. This report, therefore, covers its continuation and is written to cover the year's activities rather than the six months of my chairmanship.

UNEMPLOYMENT AND EFFORTS TO COMBAT IT

I have used the word "privilege" intentionally, because this is one of the most important efforts that our local societies have undertaken and because my contacts have strengthened my faith in the profession and in the character of the individual engineers. Our profession is self-sufficient and our brother engineers are self-reliant, sympathetic, and generous. We have asked for no contributions outside of our profession and our unemployed have asked only for work. Relief in food, clothing, or money has literally been forced on many who were destitute through no fault of their own, and the most menial job has been preferred to loans or food relief.

Of course, there have been exceptions, but surprisingly few, and these always are men who entered the profession by accident rather than aptitude, at a time when the demand exceeded the supply and when many were employed who had neither the training nor the type of character required by the profession.

Complete details of this year's work are given in the several subcommittee reports[3] included in the appendix and need not be fully discussed here, although some items are of special interest.

Since contact could not be kept with all former registrants without heavy expense, a completely new registration was opened in October, 1932; 3015 were registered this year, of which 957 were also registered during the previous year. Of this total, 50 per cent were financially able to take care of themselves; and consequently we devoted our principal efforts toward the relief of those men who were either destitute or close to destitution. Our relief has been guided by the degree of destitution rather than society membership, provided investigation of the applicant's past record showed that he was truly within the profession.

The Engineering Societies Employment Service undertook the placing of members in engineering positions. The P.E.C.U. cooperated with this service in hunting positions of all kinds, but left the engineering positions largely to the E.S.E.S. Our placement in engineering positions is consequently not a true indication of engineering reemployment, because many men not on our rolls have been placed through the E.S.E.S.

JOBS AND RELIEF FOR ENGINEERS

Engineering positions have been found for 6 per cent of our total, made work for 19 per cent, and non-engineering positions for 8 per cent. In addition, 7½ per cent have received loans totaling $8239.50; 31½ per cent have received food, clothing, shelter, medical aid, or other relief through the Social Service subcommittee; and the Women's committee alone has aided 184, or about 6 per cent of the registration. There has been some duplication, as, for example, small loans and the gifts of clothing, medical help, etc. We have lost contact with some, but our best estimate indicates that 40 per cent of the total enrolment have received some degree of help, and of the remaining 60 per cent, at least three-quarters have not required financial assistance but only jobs to maintain their morale.

We have a duty as well to these latter. We have been unable to find employment for these men and have therefore endeavored to keep them active through educational courses. Under the direction of Mr. Alfred D. Flinn, secretary of the United Engineering Trustees, Inc., a series of educational courses was given and was

[1] The Professional Engineers' Committee on Unemployment was organized in October, 1931, by the appointment of a committee of forty representing the Am.Soc.C.E., the A.I.M.E., the A.S.M.E., and the A.I.E.E. The committee was organized because of the desire on the part of the engineering societies to do what they could to save unemployed engineers in the metropolitan area of New York City from acute destitution. The work is carried on by an executive committee made up as follows: W. A. Shoudy, General Chairman; T. F. Barton, Chairman, Finance Committee and representative, A.I.E.E.; Ole Singstad, Director of Relief; Wm. Heyman, Director of Administration of Funds; E. E. Dorting, Director of Publicity; A. D. Flinn, representing the United Engineering Trustees, Inc., Treasurer; G. B. Pegram, representative, Metropolitan Section, A.S.M.E.; Sidney Ball, representative, Metropolitan Section, A.I.M.E.; Malcolm Pirnie, representative, Metropolitan Section, Am.Soc.C.E.; and Alfred H. Meyer, Executive Secretary.

[2] General Chairman, P.E.C.U., Consulting Engineer, New York, N. Y. Mem. A.S.M.E.

[3] The subcommittee reports are not to be printed in MECHANICAL ENGINEERING. Copies may be obtained by writing to the Professional Engineers' Committee on Unemployment, 29 West 39th Street, New York, N. Y.

attended by more than 200 engineers. Columbia University opened its doors, without cost, to 138 engineers certified by this committee. These valuable engineering courses have been greatly appreciated, and although the special series need not be repeated, Columbia is again enrolling engineers on the same basis.

Our enrolment does not represent the total unemployed in this district. Many have registered only with the Engineering Societies Employment Service and still more have registered nowhere and are depending upon personal contacts and their own efforts in finding employment. We have no means of knowing accurately the extent of engineering unemployment. The cost of questionnaires, we feel, had better go to direct, immediate relief, for unless followed up by personal contact, questionnaires do not bring sufficient replies to give an accurate cross-section of the profession. It is my opinion that probably 50 per cent are without engineering work and that the combined earned income in this district may not exceed 25 per cent of that of 1927 or 1928. Yet, in spite of this condition, our members have given liberally.

CONTRIBUTIONS AND WORK OF RELIEF

In the metropolitan district they have contributed in cash $52,961.91 this year, making a total contributed during the two years of operation of $160,369.87. A balance of $20,242.63 was left by the previous committee to begin this year's activities; $57,264.52 has been expended, leaving a balance of $15,798.35 to begin the coming year. All of this money has gone as direct relief to unemployed engineers. The staff is composed of unemployed engineers receiving $5 per day as salary and a few volunteers who are serving without pay. The stenographic assistance was furnished by the City Commission Work Bureau and the Gibson Committee. General expense, such as printing, postage, telegrams, etc., amounting to $5484.27, has been met by the local sections and by donations for this purpose.

Space in the Engineering Building is provided by the United Engineering Trustees, Inc., for staff offices. Contact is maintained by the staff with the various Governmental relief agencies. By cooperation with these agencies and an added expenditure on our part of $33,422 in salaries to unemployed and destitute engineers, a gross dollar value of relief of $738,651 has been obtained this year. That is, by a payroll expenditure of one dollar, we have effected relief to the value of $22.

Some idea of the mass of detail connected with this work may be gained by the records of the Placement Bureau, which handled 18,238 calls, or an average of 67 per day. The Registration Bureau has handled 3714 applications and has made 1237 investigations. The Employment Possibilities Bureau has made 3000 personal calls, resulting in 535 temporary and 345 permanent openings. Unfortunately, not all of these were filled by our registrants.

Much of the relief cannot be stated in dollar value or in statistics. It is fully as important to give some relief promptly as to give complete relief after long waiting. In fact, it is the small thing that is longest remembered in the great crisis, and sympathy is valued more than charity. This service has been carried on by the Social Service subcommittee and the Women's committee. Immediate relief in loans, not exceeding $3, food, meal-tickets, clothing, lodging, medical care, and legal advice have been given by the Social Service subcommittee, and to the Women's committee has been referred many of our most difficult cases. The dry statistics are given in the appendix, but each item carries an unwritten story of heart-break and relief and an engineer kept within his profession.

STATISTICS OF REGISTRANTS

The classification of our registrants, as given in the appendix, deserves considerable study. It must be remembered that the number so classified is small, but it represents a fair cross-section of unemployment conditions. Nearly 45 per cent formerly earned between $2400 and $3600 (with a few above $15,000) per year; and the others are about equally divided above and below this grade; 60 per cent of those who received $2400 per year or less, are under 30 years of age and a large number of these are recent college graduates. Possibly the situation is unique for depression periods, for many have not only lost their jobs, but also their savings, through bank failures and unwise investment, and some, through the purchase of employing companies' mis-named "securities." The larger registration among the lower salaries is to be expected because such men have had less opportunity to accumulate a reserve.

A condition peculiar to metropolitan areas is that the majority live in rented apartments or houses, while in the less thickly settled communities the engineer usually lives in his own house with at most a small mortgage. A number of our registrants had begun the purchase of homes and the majority of these have been unable to continue payments and have lost their property. This metropolitan condition is due largely to the fact that the location of the jobs or their uncertain tenure makes house-owning undesirable. Without employment, savings go principally to rent and are soon exhausted, while the home-owner, in spite of taxes, finds that the cost of sustenance, heat, and clothing is relatively small.

COLLEGE EDUCATION NOT A POSITIVE GUARANTEE AGAINST UNEMPLOYMENT

We have attempted to draw some conclusions from the educational background of the registrants, but it must be remembered that many, probably the majority, are unemployed because of an economic condition rather than lack of engineering education. Only one conclusion is certain: A college education is not a positive insurance against unemployment. Possibly this conclusion is worthy of study. Have our technical schools and engineering societies failed in this respect? I think so. Hardly one per cent of our engineers know how

to hunt a job. For the past 30 years the job has hunted the man. To lose a job was unfortunate but not serious, for in a short time a new one would turn up, sometimes better than the first.

STATUS OF ENGINEERS IN ECONOMIC DEPRESSION

Sixty per cent of our registrants were employed in capital-goods industries. The other third is less easily identified, but relatively few can be definitely identified with consumer-goods industries. It seems probable that the overwhelming majority of engineers employed in operating the "machine" retain their jobs, but the designer and builder must be prepared to lose his job at the first sign of economic disturbance.

The engineer has a heavy responsibility that he can shirk only at a risk first to himself. Periods of depression hit first the capital-goods industries. The engineer is the foundation of these industries and they are his means of livelihood. He is consequently among the first to suffer, but he has to a large extent the power to control that industry which supports him and he must increasingly make his voice heard.

He has been blamed by the shallow thinker for this depression and is in part at fault, not because he has built the machine, but because he has sold it without operating instructions, and has forgotten it. He forgets that the last census lists hardly more than 200,000 engineers, or one-half of one per cent of those gainfully employed. He cannot expect that the 99 per cent will understand the language of the one per cent. He must speak the language of the majority.

THE ENGINEER AN INDIVIDUALIST

The engineer must be an individualist; he cannot be otherwise and accomplish the results with which he is credited. He must necessarily go his own way, make his own decisions, fight for them if necessary, and hold to his conclusions, "in spite of Hell and high water." Unless he cares more for his reputation than his fee, he is false to his profession and not worth the fee his client pays him. He is consequently generally underpaid and acquires wealth only by shrewd investments or by entering the business phases of engineering. Although he is an individualist in respect to himself, he has long recognized the value of cooperation, has generously supported public projects, and has devoted much of his time to his professional societies. Yet he believes that each man must stand on his own feet: he welcomes advice, but does not ask for help, and has little respect for the man who cannot help himself.

He does not believe in panaceas and knows the inertia of man as well as the inertia of the steam-hammer or the river flood. He knows that great expenditures offer greater inertia than small ones, and that just as half the cost of the structure frequently lies in the foundation out of sight below ground, so any great project must have its period of slow progress for planning and foundation, if trouble and delay are to be avoided. He cannot be forced into a statement of his program until his plans are matured and he will not begin his superstructure until the foundation is laid. He is subject to constant criticism because he will not talk until he can speak with authority and has no patience with those who act without a plan or offer programs that have not been thought out.

ROLE OF THE ENGINEERING IN HUMAN PROGRESS

The engineer has been trained to reason from facts to a sound conclusion, and because of his impatience with the lack of such reasoning, he has been forced to add business and the social sciences to his studies. It is he who initiated and is leading in the development of the science of industrial management. Just as his machine has been misused, so this budding science has been seized upon as a means of quick profits rather than a basis for sound planning for an equitable division between the employer and the employed. Some few of our engineering leaders have understood our responsibility; they saw the approaching danger of technological unemployment and warned us through the American Management Association, in 1923. Elliott Dunlap Smith warned the mechanical engineers at their annual dinner, in 1930. But these voices were lost in the noise of prosperity. The engineer has proved himself a sound analyst of business methods and has put the scientific method into management; possibly he must assume the responsibility of making order out of the present chaos in the study of economics. He must at least recognize his responsibility to industry and civilization and realize that if new jobs are needed he must create them; but he cannot create jobs if he does not know how to make one for himself.

STILL OPPORTUNITY FOR ENGINEERS

In spite of his shortcomings, the engineer has been a highly important member of the community even before the records of written history. His was the inquiring mind that turned his discoveries into practical appliances for the common good. He investigated fire and learned to kindle it; he studied the rolling log and invented the wheel; he studied metallurgy and produced the iron age; he brought potable water to the villages and made them cities; his studies in statics made possible palaces and cathedrals. Watt's steam-engine restored England's coal resources; and our steamships and railways opened up this country to development. Threats of depressions have given way to new industries developed by the engineer; and in this country's history, recovery from depression periods have always been accompanied by new industries whose developments were begun by the engineer before depression began. Even today we find startling developments in railroads and street railways that threaten to revolutionize transportation on land. Probably 50 per cent of our factories have out-of-date equipment, and many processes have been completely altered. Is it too much to believe that the same type of creative engineering mind is still with us and, given the opportunity and encouragement, will create new industries which

will absorb the present unemployment and the ever-increasing supply of wage earners due to growth of population and improvement in agricultural methods?

THE ENGINEER'S DUTY TO SOCIETY AND TO HIMSELF

The engineer alone cannot restore prosperity or prevent depressions, but he can make his voice heard and understood if he will remember that he is only one per cent talking to 99. It is not enough to explain the technical details; he must learn to speak in a language that the 99 per cent will understand and interest himself in subjects not now considered the field of the engineer. There is now more work to be done than our engineers can do, for, as Dr. Arthur E. Morgan has said, "Wherever a job is not done or poorly done, there is an opportunity for a new profession."

THE RESPONSIBILITY OF THE ENGINEERING COLLEGE AND THE PROFESSIONAL SOCIETY

This is the responsibility of both the college and the engineering society. We have made no study to determine to what extent the colleges realize this duty, but Dean J. W. Barker, of the Columbia Engineering School, has recognized this need and has consequently requested me to give such a course, which has been planned in detail by Mr. Samuel S. Board. This will not be a course in "How to Find a Job," although much of the technique will be discussed, but the aim will be to impress the young engineer first with his responsibility to society and, second, how he can obtain this opportunity for service and how he can provide employment for others. At Purdue University, Dean A. A. Potter has also taken steps toward presenting a course with the same objectives.

This committee is planning a similar work. The complete plan is included in the appendix. My first duty is to attend to problems of immediate relief; consequently this plan is progressing slowly, but I am convinced that it is sound and workable and should be continued, even after recovery has begun.

WORK TO CONTINUE

I believe the two years' work of this committee has not only proved of real help to the unemployed, but has shown the value of a united voice of the local engineering society members. This advantage has never existed before in this community. We were consequently slow in getting relief under way. Official Government recognition has endorsed our efforts as being the voice of the local engineers and this advance should be retained. For years, Boston engineers have had this recognition and were immediately called upon by the local authorities when unemployment relief was necessary. It is to be hoped that this coming winter will be the last of our relief activities; but must we lose our united voice when the committee's work is done? Is it not wise to give careful thought to the continuation of some agency that will facilitate united action on the part of the engineers in the metropolitan area?

ACKNOWLEDGMENTS

The spirit of the profession is shown by the response of the individuals to the requests of the chairman and his associates. No engineer has failed to do all in his power when a request was made. The various Governmental and local committees have responded immediately to our requests and have accepted our endorsements generally without further investigation.

The general committee members have given their fullest cooperation and help to the chairman, and his immediate associates have rendered invaluable aid. I particularly wish to thank Mr. Ole Singstad, Director of Relief, for his unselfish devotion to this work; Mr. William Heyman, Administrator of Funds, for his efficient control of expenditures, for giving his time to hearing all applicants for loans, for his interest and sound counsel, and for his gift of children's shoes; Mr. T. F. Barton for his successful campaign for funds from a source fast running dry; Mr. Ralph T. Rossi, chairman of the Social Service subcommittee, for his constant interest in this phase of the service and his effective help in securing clothing; Mrs. Josephine M. Barron, chairman of the Women's committee, for her constant interest and her many unsolicited benefactions; and Mrs. Ehrmine L. Dolbear, Executive Secretary of this committee, who gave her whole time to those difficult cases referred to her, whose keen insight disclosed the essential points for relief, and whose sympathy and courage helped us over many obstacles; Mr. James McB. Webster, whose whole time has been given to this committee as Assistant Director of Relief, and later, special assistant to the chairman; Mr. Alfred H. Meyer, Executive Secretary of the General Committee who, together with his duties on the staff of the A.S.M.E., assumed any detail with unusual efficiency, throwing his whole heart into this effort. I wish also to thank, for their service for shorter periods, Messrs. Seth G. Hess, Lieut. A. G. Trudeau, and Col. H. C. Fiske.

Of the staff, nothing can be said but praise. Working under a severe strain at office and at home, beginning without the specialized experience necessary, their success is shown by the remarkable results. Thanks are due Messrs. F. A. Rossell, F. J. Rice, J. G. Addy, Jr., F. C. Czarnecki, S. E. Page, and their assistants.

THE URGE to produce is not dying, but it bids fair to be overshadowed by a rising concern to guarantee that the production of wealth shall serve broad social interest and that it shall be widely distributed, not alone as goods and economic security, but also as intangible privileges of leisure, recreation, education, and cultural activity. The era of technological pioneering is far from ended, but we may see our major efforts as a people shifting into the realm of pioneering in social and economic controls. What has the engineer to gain or lose in such a shift of emphasis and what distinctive contribution can he make to a new age?—Wm. E. Wickenden in *Jour. Engineering Education*, October, 1933.

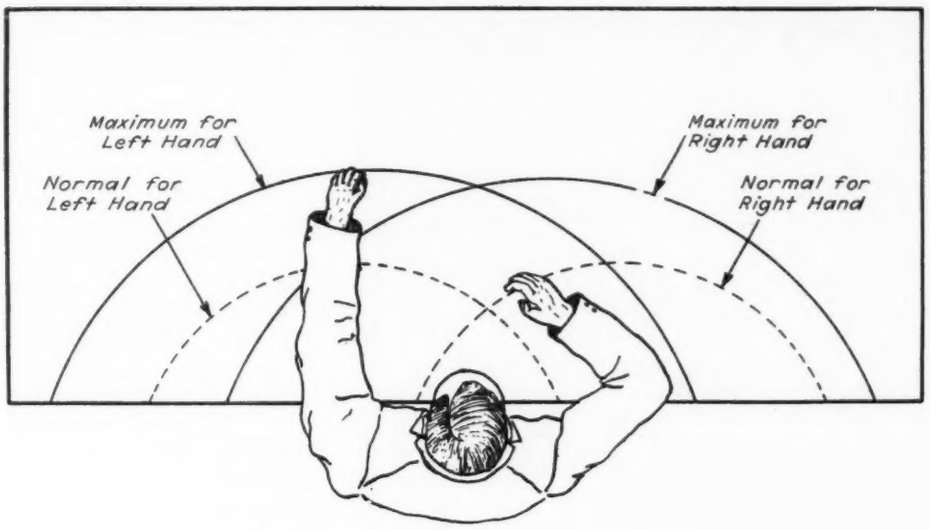

FIG. 1 MAXIMUM AND NORMAL WORK AREAS

MOTION STUDY:

Why Has the Machine Designer Ignored It?

By ALLAN H. MOGENSEN[1]

WITHOUT QUESTION, tremendous strides have been made by the designers of machines and tools. Witness, for example, some of our almost superhuman automatic equipment. Given enough money and time, I believe engineers and designers can give us machines capable of building or assembling any article, no matter how complicated. However, it is not my purpose to praise these developments, and one might, of course, question the economical justification of some of them. Personally, I believe we have had too much automatic machinery, or perhaps I should say, too much labor-saving machinery. We appear to have overemphasized the actual saving of labor. In the search for the ultimate in complete automaticity, with its corresponding theoretical low cost, we have ignored a wide range of other possibilities.

I am not advocating doing away with machines, automatic equipment, and material handling. But I believe this question should be asked in every case: Will the machine pay for itself in the continually shortening period of equipment life?

Without question, appearance and economy of manufacture should be considered in the design of equipment. Nevertheless, I believe that of far greater importance is the consideration of the human being who has to use this equipment for the rest of its useful life. It is not very complimentary to the designers of machine tools to see the numerous changes that are made to existing equipment in shops where motion study is applied—particularly when suggestions for a complete redesign are heard. It almost seems as if the men who design this equipment have no conception of the motions the operator must make in order to use it. There are countless cases in which the design of the equipment used makes the proper coordination of hand motions impossible.

There are two important reasons for this failure to take advantage of motion-economy principles: (1) a lack of a realization of the significance and importance of motion economy, and (2) a lack of understanding of the principles of motion economy. For this reason, I wish to review briefly these principles. They were formulated by the late Frank B. Gilbreth and by his wife, Dr. Lillian M. Gilbreth. Many of them have been presented to this Society in papers by these authors and others.

PRINCIPLES OF MOTION ECONOMY

There is a well-defined area within which work may be performed with a normal expenditure of energy. The area for the right hand may be indicated by an arc drawn with the right arm fully extended in front, making one sweep across the table, pivoting from the

[1] Consulting Editor, *Factory Management and Maintenance*, McGraw-Hill Publishing Co., and Industrial Consultant, New York, N. Y. Jun. A.S.M.E.

Contributed by the Machine Shop Practice Division for presentation at the Annual Meeting, New York, N. Y., Dec. 4 to 8, 1933, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Abridged.

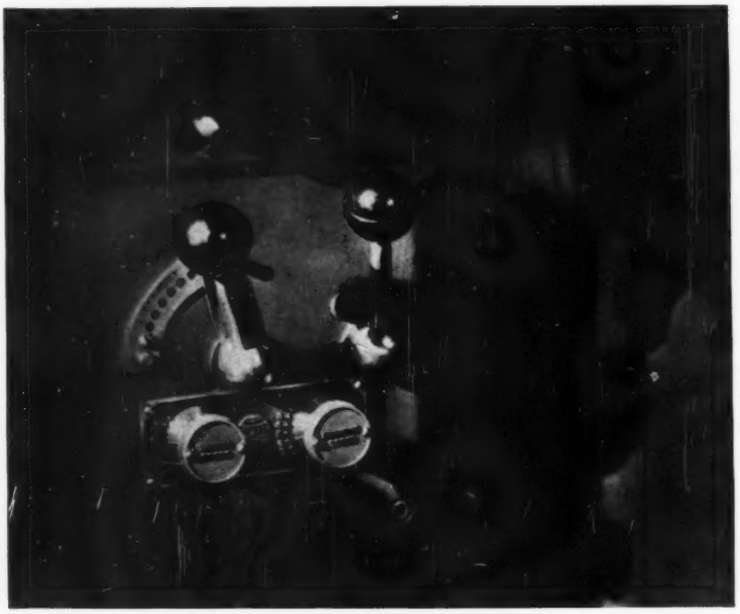

FIG. 2 ALL TABLE CONTROLS OF THIS MACHINE ARE WITHIN A 9-IN. CIRCLE

shoulder. The area for the left hand is similarly defined. These two areas are termed "maximum working areas." Work areas beyond these require additional body motions which are to be avoided if possible.

These maximum working areas are again divided by arcs drawn with only the forearm extended, the upper arm being more or less relaxed, and pivoting from the elbow which remains close to the body during the early part of the movement, then swinging slightly away from the body as the limit of the movement is approached. These last zones represent the most desirable areas within which to locate material and tools, and are termed "normal working areas." The zones are illustrated in Fig. 1.

In approaching the problem of properly placing materials and tools at the workplace, we are guided by the five classes of hand motions:

(1) Finger motions
(2) Finger and wrist motions
(3) Finger, wrist, and forearm motions
(4) Finger, wrist, forearm, and upper-arm motions
(5) Finger, wrist, forearm, upper-arm, and shoulder motions.

These are listed in progressive order, those of the first class requiring the least time and effort; and it is fundamental that motions confined to the lower classifications are preferable to those of the higher.

Machines requiring constant starting and stopping and hand-feeding or adjusting should have their various levers so positioned that the principles of motion economy may be complied with. (See Fig. 2 showing how all of the controls of a recently designed machine have been put in a 9-in. circle.) Yet in most instances such levers are arranged for kinematic or mechanical simplicity. As yet, little has been done to permit the operator to apply this simple principle of motion economy. Most machines are still laid out along straight lines. A simple example is the piano, the keyboard of which has been and probably always will be laid out on a straight line. However, when it came to the design of the motion-picture-theater organ it was realized that it would be humanly impossible to operate such an instrument if the traditional design were followed.

WHAT MICROMOTION STUDY HAS TAUGHT

Violations of the principles of motion economy are discovered by micromotion study. Through micromotion study, for example, we have learned the value of "drop deliveries." In drop deliveries, the finished article is delivered by simply releasing it in the position in which it was completed, without the necessity of moving it to dispose of it. The time saved in transporting the work to its destination is not so important here as the fact that both hands are free so that they may proceed simultaneously in unbroken rhythm—and rhythm is an important factor of skill. Few machines are designed to take advantage of this fundamental.

All tools, whenever possible, should be pre-positioned. That is to say, they should be returned to a suitable holder each time after use. This holder should be designed to allow rapid release, and also to permit the tool to be grasped in the position in which it is desired to hold it while in use.

Opportunity awaits the designer of quick-acting screw drivers and nut tighteners for small assembly operations, as most of the tools now available are too heavy or bulky. We may soon see a complete new line of small, light, material-handling equipment, to aid in many operations where continuous lifting or handling is necessary.

We have also learned through micromotion study that wherever possible hand motions should be simultaneous and symmetrical in opposite directions, and that the greatest value of micromotion training comes through the ability to visualize industrial operations in terms of motions.

We may, therefore, sum up micromotion study as including an understanding of the fundamentals of motion economy and a "motion-mindedness" which only comes through the ability to visualize the motions that are necessary to perform each step in an operation and to recognize which are and which are not good motion practise, rather than thinking of the operation in terms of its various steps.

In general, it might be said that the conventional design of equipment usually provides for the handling of only one part or one set of parts at a time. Little attention has been given to the possibility of utilizing

the operator's right and left hands simultaneously.

Where the quantity involved warrants it, automatic or semi-automatic equipment is perfectly in order; but the possibility of making surprising savings by utilizing the operator's time to better advantage through properly coordinated motions still remains. In drilling, for example, in how many cases do we find fixtures designed or equipment arranged so that two pieces may be handled at a time (one with each hand simultaneously), as shown in Fig. 3? In thousands of cases the handling of the part to and from the fixture requires time far in excess of the actual drilling time.

REDUCING IDLE MACHINE TIME

When machines have to be tended, two separate sets of motions must be provided for: (1) those which the worker uses when he is tending the machine; and (2) those which he uses to prepare tools and material for the machine while it does not require his attention. As all machines, even those that are automatic, have to be tended, it is important to consider the saving, made possible through motion study, in the time lost while they are shut down.

Few people realize for how little of the time even the best equipment actually operates during the day. It has been in bringing out this fact that the process chart and some of the newer equipment for recording idle machine time have proved their value. In a recent analysis of all the machines used in one large plant, the idle machine time was 77 per cent of the total. Handling time was 35 per cent and set-up time 13 per cent. The machines were not in use because of tool or machine breakdown and lack of work 29 per cent of the time. The time actually employed in cutting metal was only 23 per cent of the total. While many designers realize this waste, they do not always see the remedy. One designer writes: "While fully aware of this fact [that a machine would be idle 90 per cent of the time] at the time the machine was being designed, the intricacy of the machine prevented me from seeing any remedy. A micromotion study of the process was then made and the film projected one frame at a time. This study, made with a background of motion-study principles, readily gave the design requirements for a new machine. Although to meet these requirements necessitated considerable design work, the new machine proved to be only slightly more complicated than the former one, and the idle time was reduced to a small fraction of the former figure."

Another place where the motion-minded machine designer can render considerable service to industry is in the reduction of set-up time. At present, the idle time due to setting up is perhaps one of the hardest elements of cost to control. Naturally, in a mass-production plant this factor is not so vital. However, with the smaller quantities and shorter runs that are becoming more common, there is no question but that we must pay more attention to the reduction of this item. A case in point is that of a machine used to drill a certain product. It required approximately an hour to change from one size to another. Formerly this was not at all serious because large quantities permitted a run of several days at a time. Recently, however, variety was increased to the point where it became necessary to set up this machine two or three times a day. The machine was taken to the experimental department and certain simple changes were made that reduced the set-up time to five or six minutes. Machine designers should keep this point in mind, as it may spell the difference between economical operation or failure to justify the existence of the equipment that they design.

Not all of these changes need be basic or expensive. Sometimes they merely involve the controls and their placement. Many machines are equipped with numerous steam, air, and water valves. Three- and four-way valves are now available and, when properly located, often permit operation of the equipment without stooping or other acrobatic maneuvers. Once an organization becomes motion-minded, changes to existing equipment seem so simple that one wonders why the designer did not include them originally.

Some equipment can be improved gradually from time to time. In other cases, however, this may be made difficult once certain forms are established. An example of this is the ordinary office typewriter. This is a typical instance where failure at the start to analyze machine design, in order to eliminate unnecessary or uncomfortable movements, has resulted in a tremendous waste of human effort. Recent studies have resulted in the proposal of a new typewriter keyboard—a change that can be effected by any typewriter mechanic. The results secured with the simplified keyboard show that beginners were able to learn four times faster, and typists who abandoned the old keyboard learned to use the new one just twice as fast. Despite this, only one organization that I know of—a large mail-order house where motion study is now being applied in various

FIG. 3 A DRILLING SET-UP TO USE BOTH HANDS

phases of the work—has experimented with the new keyboard.

ADAPTING THE MACHINE TO THE MAN

While often many simple changes can be made with existing equipment, sometimes entire redesign of the machine is indicated. A micromotion study of a machine for threading the ends of tooth-paste tubes showed that the operator was going through the contortions of a shadow-boxer in order to load and unload the tubes. The equipment was scrapped and a new machine was built threading two tubes at one time. Inclined hoppers at either side made it possible for the operator to be seated comfortably in front of the indexing disk, and by the use of simultaneous and opposite motions he was able to load and unload with methods of least waste and fatigue.

This and many other examples indicate that until recently the emphasis in machine design and construction has been on the adaptation of the man to the machine, rather than upon the adjustment of the machine to the various human limitations in the way of posture, reach, speed, rhythm, and coordinated use of both hands. In 1911 Frank Gilbreth said: "There is no waste of any kind in the world that equals the waste from needless, ill-directed, and ineffective motions." This statement is just as true today as it was in 1911, despite the tremendous gains made along the lines of mechanization.

MOTION STUDY FOR MACHINE DESIGNERS

It is therefore an indictment of the designers of equipment and tools that so little attention has been paid to these principles of motion economy. I believe it is for this reason that management has discovered how to get along with certain of its equipment. Special fixtures and equipment are being designed, and in many instances the machine itself is being rebuilt. New machines are not being bought. And they are not being bought because the designers and builders of this equipment know less about its use and practical shop operation than do those who have to use it. Therefore, designers must understand the principles of motion economy, and apply them to every tool, fixture, and machine, looking at the proposed design from the standpoint of the man who has to use that tool or machine day in and day out, if their products are to find a market.

How is the designer of machine tools to secure a complete understanding of these principles? The average machinery builder can find little justification for micromotion study[2] in his own plant. It can pay its way only when there is sufficient repetition to justify the expense.

It is not necessary for the designer to go through this complete procedure in every instance. If he has a knowledge of the fundamentals of motion economy, many of these principles will become second nature with him as he develops new equipment. He will then begin to think of the manner in which the equipment will be used. He will see that there is a difference between the functioning of the equipment and what the operator does with his hands when using it. Training in principles of motion economy, together with knowledge of elemental motion time values, will result in the designer's subconsciously thinking in terms of elemental motions.

The best place for the designer to secure this training may be in the plant of the user of his equipment. Here the equipment will be found operating under actual conditions, and the so-called skilful operator's manner of using the equipment can be accepted as the best method.

THE STUDY OF PLANT LAYOUT

As a result of motion study, much attention is at present being devoted to plant layout.

Years ago, factory machines were belted to one long lineshaft. Then came electricity and the electric motor, followed by the group drive and individual motor-driven equipment. And yet, despite this revolutionary progress, the laying out of equipment in straight lines, with ample aisles between rows, has been accepted practise, even in shops set up for progressive manufacture and assembly.

With the coming of mechanical handling, conveyers were installed, and, unless a new plant was built, they were usually placed near the existing lines of machines. Even in many modern plants it is a common occurrence to see the operator compelled to make a complete turn, walk several steps, procure or dispose of stock, and then reverse the procedure.

In addition to the actual handling within any department, transportation from one division to another became quite a problem as plants grew in size, particularly when the generally accepted principles of process control separated the manufacturing operations and grouped those involving similar processes. All this involved planning, routing, scheduling, and dispatching, requiring many records and much transportation. Loss, spoilage, high inspection costs, considerable inventory, both in raw materials and parts in process, are but a few of the more common difficulties.

In a plant set up for product control, on the other hand, the equipment actually required to perform the operations on a particular product, or a similar line of products, is set up in the correct sequence, and the product is transported as little as possible.

The layout of such a plan was subjected to motion-study analysis. The existing layout was one of typical straight lines, plenty of aisle space, ample distance between machines, and large numbers of stock containers. A diagram of the new layout that resulted from the analysis looks as if some one had just thrown the templets representing the machines on the drawing board. Yet floor space was reduced 40 per cent. Manufacturing costs were reduced. The investment in machines and stock containers dropped several thousand

[2] The procedure followed in making a micromotion study is described in Trans. A.S.M.E. (1927–1928), paper MAN-50-17a.

dollars in one department alone. Chutes were used between operations when machines could not be located to permit combination of several cycles. In one instance a milling machine and two drill presses were grouped together for one operation by one man, thus eliminating walking time, turning around for stock, taking the work out of trucks and tote boxes, and putting it back again.

This new layout was directly the result of a program of education in motion economy for the entire supervisory force in this plant. It became apparent that here motion study meant more than analyzing only the actual motions of the operator. Every operation is studied first with a view to eliminating it entirely if possible, then to combining it with some other operation, then to changing the sequence of operations with resulting economy in transportation, and finally, and not until then, to simplifying the operation itself.

RELATION OF PLANT LAYOUT TO MACHINE DESIGN

If such a fundamental change is taking place in the conception of plant layout, it will be necessary to consider the design of equipment in a different light. No longer will each machine be considered as an individual unit, to be placed on a concrete foundation with lots of aisle space around it and provision made to bring the work to and from the machine. Instead, equipment will be thought of as but one of many component parts, comprising a manufacturing unit set up for a particular operation—perhaps to be moved to a new location as the model or product changes. Machines equipped with complete control equipment that can be readily moved as a unit are already found in several plants. Some plants are wired with overhead ducts, or are even equipped with cords and plugs that permit equipment to be moved with no more thought than we give to shifting a desk lamp or an electric toaster, indicating that plant layout is no longer being regarded as something permanent. In fact, with this type of equipment, some plants are finding it economical to set up a line of equipment and run the work through, even though it is a comparatively small order. Moving costs are actually offset by savings in handling and trucking, reduction in stock and inventories, reduction in supervision and inspection, elimination of paper work, and savings in floor space.

It is obvious that the close grouping of machines will require some change in the design of equipment. We may even see the day when a purchaser may specify right-hand or left-hand control in order to allow operation of the equipment and certain other machines by one operator.

Therefore, I believe that the manufacturer and designer of equipment can no longer overlook the importance of motion study as it applies to his product. I believe success in this field will be based largely on his ability to adapt himself to these new and changing conditions. This is illustrated by the case of a manufacturer whose engineering department was equipped for motion study.

RESULTS FROM MOTION STUDY

Due to the fact that production was slack, the men in this plant who had been doing motion and time study had very little to do. The manufacturer did not want to let these men go, and, therefore, thought it might be a good thing for them to go around with his salesmen to see if they might not get some ideas regarding the use of their equipment. Some of these men returned with surprising stories regarding inefficiency in the customer's use of their equipment, and this started a program that has since been responsible for practically all the sales of equipment this manufacturer made in 1932. He asked permission from users of his equipment to let his men go into their plants and make motion and time studies. As a result of these studies, new equipment was designed and recommendations made, which in many cases resulted in the sale of new equipment to the customer, who, in turn, secured lower production cost.

Another instance, this time in the machine-tool field, is that of one manufacturer who has been selling "guaranteed production" instead of individual machines. He goes into the customer's plant, makes a thorough study of his needs, and then designs a complete production unit, guaranteeing results when this equipment is set up and operated.

These examples, of course, may be carrying my original thesis to an extreme. Nevertheless, I believe we cannot overlook the importance of motion study in the examples given. The motion-minded factory man sees that any operation is made up of three parts—"make ready," "do," and "put away." We have gone a long way in improving the "do" part of any operation. Modern equipment, high-speed tools, automatic machinery—all these have helped solve this phase of the manufacturing cycle. We must now look to the "make-ready" and "put away" for our savings.

In one Mid-Western concern, where a regular program of motion economy is followed, training courses for various factory groups are offered, one man studies the jobs with a view of changing tools and equipment through motion study. Two years' work shows the following results:

	1930	1931
Total number of jobs improved...	58	39
Total savings, dollars.....	37,178	51,368
Total tool and equipment cost, dollars.....	3,197	2,651
Annual net savings, dollars.....	33,981	48,717
Average time saved, per cent.....	45.2	38.1
Tool and equipment cost in terms of total savings, per cent.....	8.8	5.1

Admittedly, this is a good return on the investment, especially in a period of greatly diminished business activity. As a result of this work, every foreman now checks over every new job coming into his department to see if principles of motion study have been applied.

(Continued on page 774)

Depreciation of

TEXTILE MACHINERY

By A. W. BENOIT[1]

THE QUESTION of depreciation as applied to textile machinery has attracted much attention from textile-mill owners, engineers, and accountants during the past few years. There has been a wide variance of opinion as to how it should be figured, what should be included, the proper amounts to apply, and, having arrived at some answer, what should be done with it. Government officials, mill owners, engineers, and accountants approaching the problem from different angles, have at times arrived at widely differing conclusions, so that one gets the impression that "depreciation" is an elastic quantity to be expanded and contracted to produce some desired combination of figures.

Rates of depreciation on a given machine may change, but the factors which enter into the determination of the proper amount of depreciation should not be ignored nor should arbitrary figures be used in order to improve the appearance of a situation.

Depreciation is the shrinkage of value. It is generally expressed as a percentage which is the increment to be deducted from the original cost or the replacement cost to determine the book value at any given time.

The three main factors which influence the amount of depreciation to be applied to any textile machine are age, wear and tear, and obsolescence.

AGE OR NORMAL LIFE EXPECTANCY

Age, or normal life expectancy, is obviously one of the principal determining factors in the amount of depreciation to be deducted each year. It is difficult to draw any fine line between "age" and "wear and tear" because one is to some extent a factor of the other, but for most classes of textile machinery there is a fairly well-recognized age limit. However well a machine may be built, and irrespective of its upkeep, the time eventually comes when, for one reason or another, it cannot be operated economically. The number of years a machine may operate will vary considerably, depending on the character of the construction, the operation it performs, and its operating speed, whether or not water and steam are used in connection with it, and the treatment it receives at the hands of the operator. From the day it is started up, a gradual deterioration goes on in a machine, imperceptible at first, but becoming apparent with the years, until accumulated infirmities overcome it and it is fit only for the scrap heap.

This period of life for some machines may be as short as 10 or 15 years, and for others occasionally as long as 50 years. For instance, dyehouse and wet-finishing machinery deteriorates rapidly and, in spite of replacement of parts and repairs, has a relatively short life. On the other hand, machines that are in dry, favorable locations and run at moderate speeds, such as cards, could be operated for many years if age were the only factor. Many machines 35 years of age or older will be found in active production in textile plants. Mechanically, they are still in fair condition, and, were that the only factor, they might be used for several years more. From a study which was made in 1930, it was estimated that 60 per cent of all the cotton spindles in the United States were more than 20 years old. Of these, a great many must have been more than 35 years of age. Mechanically they might still produce if other factors did not make their operation difficult or even impossible.

WEAR AND TEAR

But age is only one factor; of equal importance is "wear and tear." The depreciation from this source is dependent upon the conditions under which a machine is operated, the hours of operation, and the amount of repairs which are expended upon it. Machinery located in rooms in which there is sufficient humidity to cause the rusting of working parts, as in dyehouses, or where there are acid fumes to corrode metal parts, as in carbonizing rooms, or sufficient dust to make lubrication difficult, as in picker rooms, will wear out faster than will machinery which is operated under more favorable conditions. If the lubrication of machinery is systematic, regular, and thorough, there will be less wear than if there is only haphazard and infrequent lubrication.

The number of hours of operation per year has a very definite effect upon machine life. The length of the usual working year is from 2400 to 2700 hours. If the machinery is operated on two shifts, or about 5400 hours a year, it will wear out much faster than machinery which is run on only one shift.

The maintenance of machinery by the replacement of worn parts, thus keeping it in good working condition, will lengthen its operating life but not beyond the time when its advanced age would naturally retire it. It is a common fallacy to assume that the life of a machine kept in excellent repair is indefinite.

OBSOLESCENCE

While the life expectancy of any textile machine can be reasonably predicted in so far as age and wear and tear are concerned, there is still much uncertainty when the element of obsolescence is considered. And to add to the difficulty, it is obsolescence which, at the present time, is the principal factor in retiring machinery.

A machine may become obsolete as the result of (1) an improvement which improves the quality, or increases the quantity, or reduces the cost of the product to such an extent that machines of the old model can no longer compete; and (2) a radical change in the character or finish of fabrics demanded by the public or a permanent style change which renders a machine useless to the industry. This does not apply to the seasonal style changes which leave small groups of machinery idle for a portion of every year.

No time element is attached to obsolescence. Either of the just-mentioned causes of obsolescence may reduce a new machine to its junk value in a short time.

Again, obsolescence may be the result of making a great

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many more or less minor improvements to a machine over a period of years, which, in the aggregate, make possible a much superior model and render the older machines worthless. In such cases the depreciation due to obsolescence is increased with each improvement and, theoretically at least, the amount of this depreciation can be ascertained at any time by comparing the machine with the latest models with reference to quality and quantity of product. The annual cost of operation in excess of that of the new machine, properly capitalized, represents the depreciation due to obsolescence. This is an annual charge which would start when measurable improvements are made, and it increases with each such improvement.

One saving feature of these situations, however, is the time element which prevents new improvements or new models from being put into operation in quantity as soon as they are brought out. This is due sometimes to the lack of financial means, partly to the inability of the machine manufacturer to supply the demand all at once, and partly to the inherent natural resistance of mill owners to innovations until they have proved themselves. Therefore, until an improved or new model is being used by a sufficient number of competitors, so that its lower operating cost is a determining factor, the mill with the older equipment is under no particular disadvantage.

In attempting to set up definite annual amounts for depreciation due to obsolescence, one is confronted with many difficulties. The time element is so variable that it is not possible to draw any conclusions. There are periods of great activity among the machinery builders in redesigning their entire lines, during which obsolescence is very rapid, followed by periods of lesser changes and less obsolescence.

SETTING THE RATE OF DEPRECIATION

Depreciation, therefore, is a composite quantity made up of losses due to age, wear and tear, and obsolescence. The depreciation used is not necessarily the sum or the average, but the greatest of the three. Each of the three elements, when applied to a particular machine, might give a different annual rate, depending on the conditions surrounding it. Of these different rates, it is evident that the one which gives the shortest life governs, and is the rate which should be used.

In one case, where there is no appreciable wear on parts and no change in design, it might be the gradual deterioration of age alone. The rate arrived at in this case is invariably low and is not ordinarily a governing factor.

The wear and tear on a wide variety of textile machinery is quite severe, and even though repairs are consistently and carefully made, there is a definite limit fairly well established beyond which it is not economical to operate it. From our observation, we would place that limit at from 20 to 35 years, depending upon the particular type of machine. These figures give another rate of depreciation which is usually higher than that obtained from age alone.

When we attempt to set an annual rate of depreciation covering obsolescence, we are in difficulty because we are trying to forecast future development in machinery and its effect upon the useful life of a machine. In the case of any one type of machine this would be impossible, but some general conclusions can be arrived at from past experience and the trend of the times. In the period prior to 1920, comparatively little progress was made in the development of new textile machinery. This does not mean that there was no development, but that it consisted largely of minor improvements to existing machinery, which made existing machinery obsolete only over a period of years. In the few cases of outstanding improvements there had not been a sufficient number installed to control the market prices. The relatively large amount of textile machinery which was more than 25 years old and which was still operated successfully in competition with newer machinery is evidence that this was so. However, since 1920 there have been many radical departures in design and consequent improvements in quantity and quality of production, with a lowering of labor costs, so that many machines which date beyond 1920 are obsolete. There has also been a keener appreciation of the advantages of the improved machines by the mill owners, and the period between the offering of improvements and their general adoption has been shortened. It seems probable that the present trend of textile-machinery manufacturers to continue research and experimental work will continue for some time, and that the next ten years will show as great an improvement as the past ten years. The depreciation for obsolescence on textile machinery must, therefore, be liberal to take care of this condition. While it is impossible to say which machines will be affected, or the degree of obsolescence that they will suffer, it is certain that obsolescence will occur and average rates must be used on all machinery, sufficient to cover this expectancy. It is generally agreed that this should not be less than five per cent per year, and might be as high as ten per cent.

VALUE OF KNOWING AMOUNT OF DEPRECIATION

The amount of depreciation having been determined, it has various uses, as follows:

(1) It represents the decrease in value of the physical part of the plant and is deductible from the book value to get the present worth.

(2) It is the amount of the capital investment which is worn out and is a charge against manufacturing costs.

(3) It is the amount which should be set aside as a reserve each year to replace the original machine, or its equivalent, when it is worn out.

The depreciated value, which is found by deducting the total depreciation from the replacement or original cost, gives a figure which may have little or no relation to actual value. Changes in the industry, such as drastic changes in costs of machinery, overexpansion, underconsumption, or other agencies, may deflate values to a point far below book values; or contrary changes may increase market values above book values. Both have happened in the past twenty years.

Obviously, for cost-accounting purposes, book values cannot be changed to meet the rapidly fluctuating market values which are prevalent in these times. The depreciation is necessarily based on fair book values as represented by actual expenditures for machinery.

The amount by which machinery is depreciated, or worn out, or made obsolete each year is as much a part of the costs of operation as labor or raw stock and as such must be included in the cost of manufacturing. While this principle is well recognized in mill accounting, it has not been sufficiently well understood, nor has a standard practise been established so that similar mills can use similar figures. The situation is growing better, however, much thought is being given to the subject, mills are comparing and agreeing on certain principles and figures, and some semblance of order is evolving out of the chaotic condition of the past.

When the amount of annual depreciation of textile machinery is set aside each year as a reserve to replace the machinery on its retirement, there are some other factors to be considered. During the useful life of a machine there is likely to be a considerable change in its cost, due to changing commodity prices or to improvements in the machine which increase its cost. The accrued amount at its retirement should be sufficient to

replace it. Depreciation for this purpose should be figured on replacement costs. Evidently new book values cannot be established each year, but they can and should be corrected at reasonable intervals to keep book values somewhat in line with actual replacement costs. In this way the reserve set up will actually replace the machine on its retirement at the then-existing cost. Because of the indeterminate factor of obsolescence, this can be only approximate.

Many textile plants operating over long periods of years have not made proper provision for the replacement of worn-out machinery by the setting aside of adequate reserves as indicated by the annual amount of depreciation of textile machinery. They have, in fact, returned to the stockholder much of their capital in the form of dividends and have been unable to make major machinery replacements except by some plan of financing which obligated future earnings. To insure continuity in business, to preserve the original investment in textile machinery, and to provide for replacements, reserves equal to the accumulated depreciation should be available.

METHODS OF FIGURING DEPRECIATION

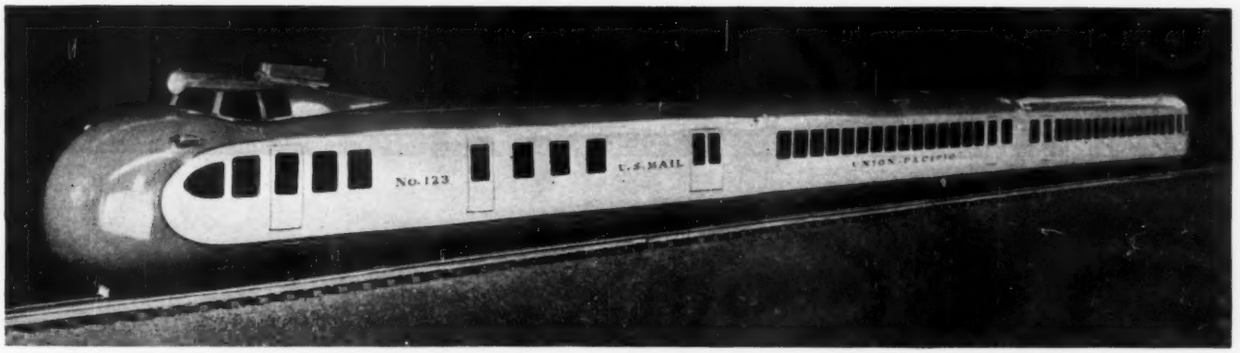
Many schemes of figuring depreciation on machinery have been evolved, but in general two methods are used. One is the straight-line method, in which the same amount of depreciation is taken each year from the time of its installation, producing a reserve of constant growth. The other is a curved-line method, sometimes called the asymptotical method, in which the same yearly rate of depreciation is used but is applied to the remaining value each year. Other methods use a varying rate of depreciation generally starting with a higher rate and gradually reducing it. This builds up a reserve much faster in the earlier and presumably most productive years of the machine, and annual increments to the reserve become less as the machine requires more repairs and upkeep.

Each method has its ardent advocates, and presumably either can be used as conditions demand. The straight-line method is simpler to apply and serves all practical purposes for which depreciation is figured.

If the usable life of a machine is estimated in years and a rate of depreciation is set up to produce a reserve equivalent to its replacement cost in that period, it is obvious that no further depreciation need be figured on that machine at the expiration of that time. The machine may operate some time beyond its allotted life, particularly if obsolescence has not taken place, without further reserve against it. On the other hand, if, because of unexpected obsolescence, its life is shorter than estimated, the remainder of its replacement reserve must be set up when the machine is discarded. Such refinements are possible only when a very accurate machinery account is kept, which is generally not the case. As a rule, machines of like use and of the same estimated usable life are bunched together and the depreciation is applied to the whole. In many cases a general figure is used covering all the textile machinery in a plant without reference to its usable life. The total amounts obtained from such figures may be very close to those obtained by a careful segregation, and for some purposes answer all requirements. For setting up departmental costs, however, particularly where there is a wide difference in the usable life of machines, some method of treating each group would seem more desirable.

The very active part which the Federal officials are taking in the determination of rates of depreciation on textile machinery is keeping this question in the foreground. There have been many hearings and much discussion, out of which it is hoped some definite principles will be set up. The actual rates to be applied to any particular machine must necessarily depend on many variables to be determined for the machine or group of machines under consideration.

Ewing Galloway



THE HIGH-SPEED, LIGHT-WEIGHT PASSENGER TRAIN UNDER CONSTRUCTION FOR THE UNION PACIFIC RAILROAD

Light-Weight, High-Speed PASSENGER TRAINS

By E. E. ADAMS[1]

THE PUBLIC is probably generally aware of the fact that the passenger business of the railroads has been declining steadily in recent years because of the competition of the motor bus, the private automobile, and, recently, the airplane. In order to show the extent of this decline, compared with the increase in automobiles registered in the United States, the following figures are quoted from "Railroad Facts," published by the Western Railways' Committee on Public Relations:

Year	Passenger Miles	Automobiles Registered
1911	32,371,444,793	619,500
1916	34,585,952,026	3,297,996
1920	46,848,667,987	8,225,859
1921	37,312,585,966	9,483,391
1922	35,469,961,582	10,959,571
1923	37,956,594,827	13,539,608
1924	36,090,886,478	15,460,649
1925	35,950,222,811	17,496,420
1926	35,477,524,581	19,237,171
1927	33,649,706,115	20,219,223
1928	31,601,341,798	21,379,125
1929	31,074,134,542	23,121,589
1930	26,814,824,535	23,059,262
1931	21,894,420,536	22,347,800
1932	16,974,591,000	20,903,422

Coincident with this decline in passenger business, the railroads have spent enormous sums of money for the replacement of light wooden equipment with heavy steel equipment which has very radically improved the safety and comfort of railroad travel. A modern ten-car passenger train, consisting of locomotive, head-end car, de luxe coach, diner, six Pullman sleepers, and observation car weighs approximately 2,000,000 lb. An average of 100 passengers per train is considered a very satisfactory volume of business, which means a dead weight of 20,000 lb per passenger. An ordinary 30-passenger bus weighs around 20,000 lb, or about 667 lb per passenger. An average five-passenger automobile weighs about 4000 lb, or 800 lb per passenger. The result is that in recent years, with a few exceptions, the passenger business of the railways has been unprofitable when all costs are properly prorated.

There is a strong demand on the part of the public for increased speed, and with the present heavy class of equipment, such increase can only be made by shortening trains or increasing the power of locomotives, thereby materially increasing operating cost; and the possibilities of increased speed even under these conditions are very limited.

A SUGGESTED SOLUTION OF THE PROBLEM OF HIGH SPEED

The obvious solution appears to be the development of light-weight, high-speed trains which can be operated at a minimum of expense, and such a development has recently been undertaken by the Union Pacific Railroad Company with the Pullman Car & Manufacturing Corporation as the builder. A three-car train is nearing completion, consisting of a forward car containing the power plant, a 33-ft mail apartment, and a small baggage room; a second car, which is a coach, seating 60 passengers; and a rear car, which is a coach, seating 56 passengers, with a buffet in the rear for serving light meals to passengers at their seats. See Fig. 1.

LIGHT WEIGHT

A study was made of all available materials, including the aluminum alloys, stainless steel, and other steel alloys with physical properties intermediate between ordinary steel and stainless steel. In order to obtain extreme light weight, the choice narrowed down to aluminum alloys versus stainless steel. It was finally decided to use aluminum alloys for the entire car structure, except for the bolsters, articulation castings, and truck frames, for which purpose there was used a special alloy cast steel having high tensile strength, high yield

[1] Vice-President, Pullman Incorporated, Chicago, Ill.

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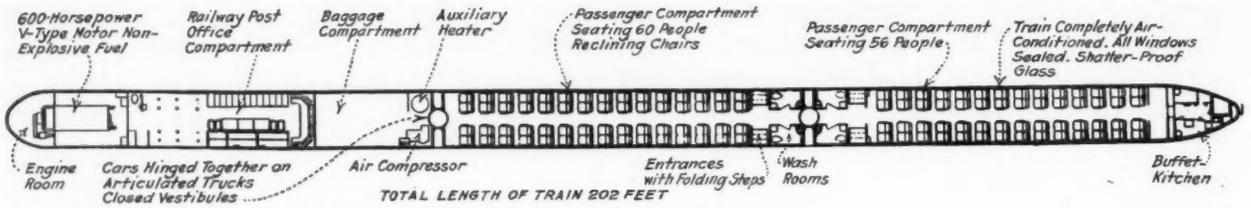
600-Horsepower V-Type Motor Non-Explosive Fuel
Railway Post Office Compartment
Baggage Compartment
Auxiliary Heater
Passenger Compartment Seating 60 People Reclining Chairs
Passenger Compartment Seating 56 People
Train Completely Air-Conditioned. All Windows Sealed. Shatter-Proof Glass
Engine Room
Cars Hinged Together on Articulated Trucks Closed Vestibules
Air Compressor
Entrances with Folding Steps
Wash Rooms
Buffet-Kitchen
TOTAL LENGTH OF TRAIN 202 FEET

FIG. 1 PLAN OF HIGH-SPEED TRAIN

point, and great ductility. The net result is an estimated weight of 160,000 lb for the three-car train.

A number of factors led to the adoption for this particular development of the aluminum alloys as against special alloy steels, but it should not be inferred that it is believed that aluminum alloys will be the one material suitable for such construction. The development of aluminum alloys has been the object of some very progressive research work as applied to new methods of car construction, the most interesting being the use of extruded metal shapes to take the place of the ordinary rolled shapes and pressings. These shapes are produced by merely forcing the hot metal through a die forming the cylinder head of the press. The producers of aluminum have cooperated with the car-builders and have been able to produce all of the desired shapes as outlined by the car designer with a relatively small outlay for dies, and such shapes are so accurate in dimensions that the designer is able to interlock various extruded-metal sections or shapes to produce cars of a minimum weight, maximum strength, and minimum deflection with simple shop fabrication.

Fig. 2 is a cross-section of the light-weight train showing the various extruded sections which were used throughout the structure.

Aluminum plates can also be readily formed for the curved surfaces used in connection with streamlining. Aluminum can be readily riveted and spot-welded without injury to the material. All of these factors contributed to the selection of aluminum for this first development. It is believed that a great deal of development work will be done in connection with the use of high alloy steels, with the result that there will be strong competition between different materials in connection with producing the eventual light-weight passenger-carrying equipment.

STREAMLINING

An exhaustive study was made of streamlining with the idea of reducing as much as possible the wind resistance to secure the obvious economy in power requirements. Advantage was taken of work done along these lines in connection with aircraft development. This, however, did not take into account the effect of ground resistance. It was concluded that an actual wind-tunnel test for each model or modification of it was necessary. Wooden models of the train, with detachable fronts and rears, were built, and front ends and rear ends of various shapes were constructed, all of which were subjected to wind-tunnel tests. Based upon the results obtained in these wind-tunnel tests, the final form of the train was determined, and a fairly accurate estimate was made of the power required for the speed desired.

The streamline models indicated a smooth canopy closing up the gap between sections, which is, of course, absolutely essential; but the accomplishment of this was a difficult task, taking into account the relative movement between car sections on curves. An aluminum shield which is the prolongation of the car contour, extends from the rear end of the forward section toward the front end of the following one. The extent of this projection is contingent on the minimum radius of curve to be negotiated. Closing up this gap between the hood projection and the following car section is a rubber sheet rigidly attached to the following car section, assuming the contour of the car and free to move at its forward edge. Spring actuated arms, mounted on the drum portion of the articulation with rollers bearing on the inner side of the projecting hood,

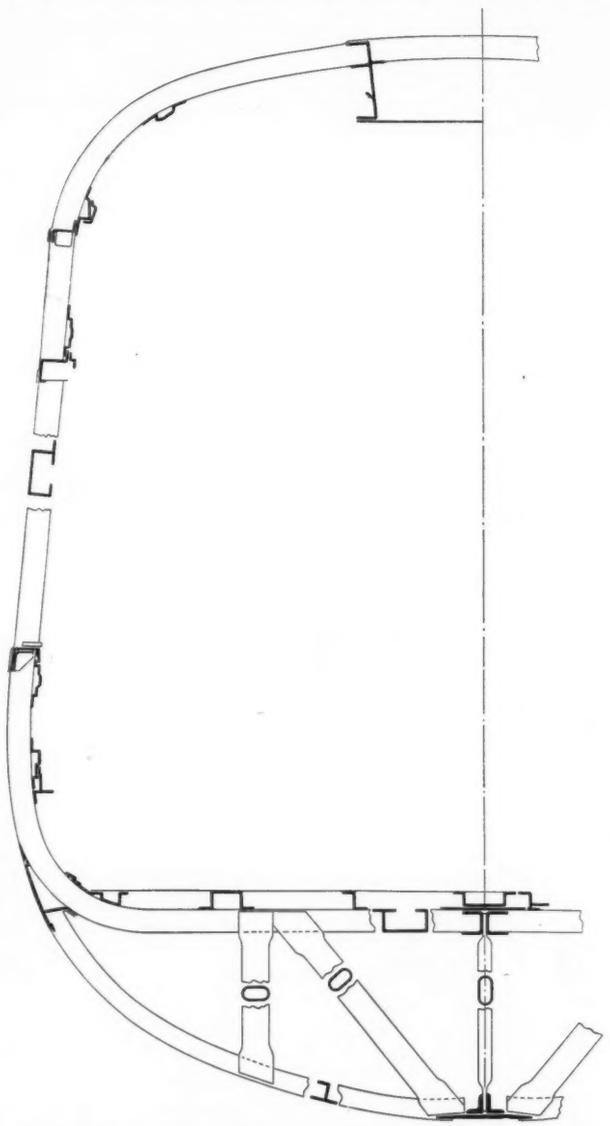

FIG. 2 CROSS-SECTION OF FRAMING SHOWING VARIOUS EXTRUDED SECTIONS USED FOR THE STRUCTURAL MEMBERS

keep this rubber stretched to close up the gap between the hood and the following car section.

STRUCTURAL DESIGN

In order to secure the greatest strength with the least amount of material, a train of tubular cross-section was adopted, with the outer surfaces of aluminum sheets and frame-work built up of extruded aluminum-alloy sections. See Fig. 3. All of the metal in the framing is coordinated to act as a unit, whether for draft or buff, as it is impossible to deflect or stress any member without having adjacent members bear their proportion of the stress. This is at variance with the ordinary form of car design where draft or buffing shocks are taken by longitudinal underframe members. The underframe transmits certain loads to the side frame and the roof, but due to its design, only part of its area can be utilized for load carrying; in other words, in the conventional type of car construction, much of the material or section does not take its proper part in bearing its share of stress.

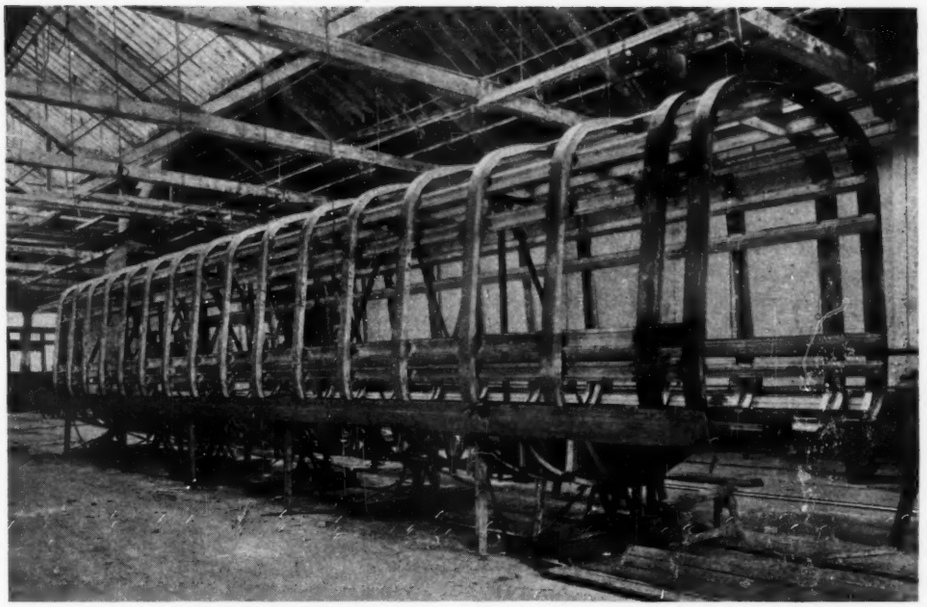

FIG. 3 FRAMEWORK OF THE HIGH-SPEED TRAIN SHOWING TUBULAR CONSTRUCTION

Assuming the cross-section of the car to be a tube, there was naturally obtained a very large moment of inertia, which means closely controlled deflections, compensating for the high deflections otherwise produced by the low modulus of elasticity of aluminum.

The basic principle that has been developed in connection with these structures is that gusset connections should be avoided; all longitudinal members should extend the entire length of the car section, and transverse members should be in one piece for at least one-half of the cross-section.

As will be noticed from the cross-section, Fig. 4, below the roof is a duct running the entire length of the car, which is used as an air duct, also for lamps for indirect lighting. This duct acts as an effective compression member. It will be noted that the underframe portion of the cross-section is an I-beam built up of extruded metal and truss bracing. This, due to its shape and connections, forms an effective tension member that coordinates with the compression member in the roof.

Incidentally, the tubular design, which lends itself to economy in material requirements, also conformed to the best shape as developed in connection with streamlining, reducing very materially the retarding effect of side or quartering winds. Our memory of the days when we rode bicycles would lead us to believe that a straight headwind is of greater resistance to speed than any other. It has been determined, however, that a quartering wind confronting the train from either side actually offers the greatest resistance because of the larger surface area presented to the forces present in the air current.

The net result of the light-weight and proper streamlined shape was rather graphically expressed by a well-known aeronautical engineer, who supervised the wind-tunnel tests and who said that the new train "has possibilities of power economy not possessed by any other known vehicle."

"The new train will require 500 hp to propel it 90 mph with a load of 120 passengers and 25,000 lb of mail and baggage. The ten-car conventional train which it replaces, carrying the same load at the same speed, requires 3400 hp; a three-car conventional train requires 1700 hp; six buses, similarly loaded, same speed, 1500 hp; 30 automobiles, 3600 hp; a river steamboat, 211,000 hp; and 15 transport airplanes, 5000 hp."

Whenever light-weight equipment has been proposed, the usual reaction of an experienced railroad man is the hazard encountered at grade crossings when colliding with automobiles, trucks, etc., which, unfortunately, is of frequent occurrence. In order to protect against damage under such conditions, the front end or nose of this train was given most careful consideration. About half of the total weight of the train, or 80,000 lb, is carried on the front truck, which necessarily requires a very massive support for the engine at the floor line. This floor-line construction forms the center of the curved front end, and all of the structural members converge to form a strong parabolic arch, which should resist without damage the shock of any collision possible at highway crossings. See Fig. 5.

ARTICULATION

Articulation of body units of the train has been adopted as best suiting the requirements for high speed and smooth riding. It eliminates the objectionable overhang of non-articulated cars, also the necessity for couplers and draft gears and complicated vestibule arrangement. It also prevents, except to a limited degree, the independent oscillation of each individual car, thus tending toward a gliding motion of the entire train. It also permits the carrying of three cars on four trucks rather than six trucks, thus reducing track resistance as well as inspection and maintenance, and, incidentally, construction cost and weight.

Articulation is effected by attaching an extension casting to each adjoining end sill, these castings terminating in center plates which rest one on top of the other, these two center plates in turn resting on the truck center plate. A heavy locking king-pin secures all three plates together. All center plates are lined with "oilite" bronze to reduce friction. Side bearings are spaced each side of center plates and are of special de-

sign, incorporating the use of rubber in shear, to deaden oscillation and contribute their share toward smooth riding.

TRUCKS

All trucks are of the four-wheel type.

The front or power truck has 36-in. rolled-steel wheels and roller-bearing journals spaced outside of the wheels, due to space necessary for the two 300-hp ventilated motors of suspended type and geared to each axle. The armature shafts are also on roller bearings, the armature being wound for a safe maximum speed of 110 mph. The remaining three trucks have 33-in. rolled-steel wheels, and all axles are provided with inside type

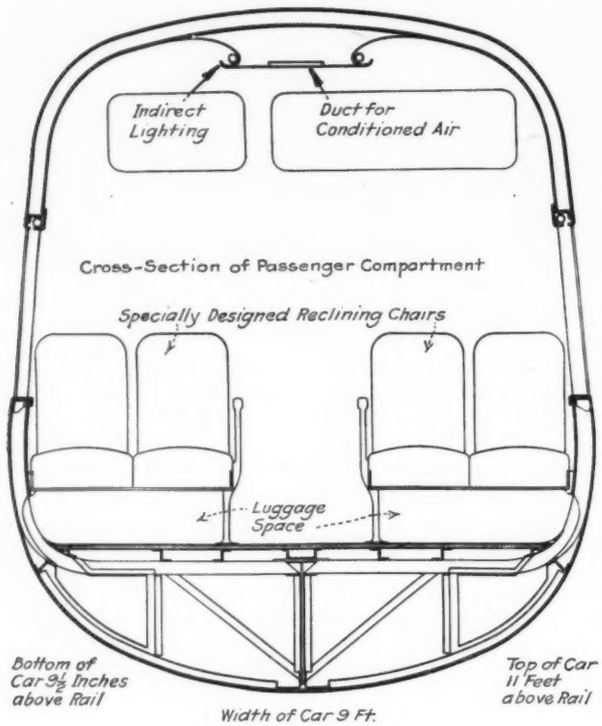
Indirect Lighting
Duct for Conditioned Air
Cross-Section of Passenger Compartment
Specially Designed Reclining Chairs
Luggage Space
Bottom of Car 9½ Inches above Rail
Top of Car 11 Feet above Rail
Width of Car 9 Ft.

FIG. 4 CROSS-SECTION OF THE HIGH-SPEED TRAIN

roller bearings, the inside type being used to reduce air resistance. All roller bearings are liberally oversized for the weight and speed requirements of this train.

To minimize air resistance still further, all trucks are shrouded, wind-tunnel experiments on scale models having developed that the total air resistance of the train was thus capable of being reduced about 20 per cent from the truck shrouding alone. An intensive study was made of the basic requirements for a truck suitable for service of this type.

Few data were available concerning the stresses and deflections in trucks set up under operating conditions. By the use of extensometers and deflectometers, the builders of the train have studied truck action to obtain a true basis for correct design, resulting in low uniform deflections in connection with low uniform stresses for all parts of the structure. This insures, under dynamic conditions, the same safety as is indicated by the usual calculations covering static loading. Localization of stress must be avoided in all successful light-weight structures and material used only where it serves a purpose. There are instances where the static stresses have been quite low at all points, but under impact, the stresses at certain points exceeded the elastic limit of the material.

The trucks on this train are of cast steel; frames and transom being cast in one piece. An alloy cast steel was used, having a minimum yield point of 50,000 lb per sq in. and extreme ductility.

The advent of light-weight cars, with high-speed trains, high accelerations and decelerations, insistence by the public on elimination of noise, comparison with the automobile and the cushioning effect produced by its rubber tires, have resulted in a steadily growing sentiment that there should be something done along these lines by the designer of rail equipment.

To meet this ever-increasing demand there have been several applications of rubber to both new and old trucks. New types of rubber compounds have been developed to meet the requirements of shear and compression loading, with proper movement under the imposed loads, and having relatively long life. The American Electric Railway Association has long felt the need for this development, and through their President's Conference Committee on Research, of which C. F. Hirshfeld is the director, they have made a very valuable contribution on the use of rubber in trucks. The Pullman Car & Manufacturing Corporation has been actively engaged in the same field for the past seven years. The trucks of the light-weight train are designed to incorporate the use of rubber to its fullest extent where there is sufficient background to warrant its adoption.

The trucks other than the power truck have inside journal bearings, and in lieu of the usual pedestals, the side frame has cutouts approximating the opening in the pedestal; but there is no metallic contact between the frame and any part of the journal box. The car weight is transmitted to the axle by means of rubber "doughnuts" (a Hirshfeld development) placed on each side of the axle. The sides of the journal box are extended either side of the axle, and between these extensions on the side frame are the rubber doughnuts, applied with sufficient compression so that the rubber has ample capacity in shear to perform its part in supporting the load, acting through the truck. In addition, there are coil springs working in parallel with the rubber so that for the usual static loading the doughnuts are lightly stressed. The compression load curve of the coil springs is much flatter than that of the rubber, so that the major portion of all impacts or live loads are carried by the rubber, the action of which is obvious. The rubber doughnuts are not only useful for vertical impact but, within a limited range, provide universal resistance, cushioning flange pressures and fore-and-aft forces, due to deceleration and acceleration.

All coil springs are mounted on rubber pads especially designed to soften shocks and "kill" metallic contact.

Rubber bushings are applied at each end of the truck bolster, the movable end bearing against hardened steel wear plates on the truck side frame, these to supplement the swing hangers in order to render them self-centering and provide a cushion effect.

Rubber is also used in connection with the chafing plates between the bolster and the transoms at the extremities of the bolster, thereby cushioning the traction and braking forces.

It was desired to use some form of shock-absorbing or resilient wheel, but the developments, although giving much promise, have not gone far enough at this time to warrant a departure from standard wheel practise. It might be added that the applications to date have been confined to wheels subjected to speeds not exceeding 50 mph. The conditions, as will be readily conceived, are quite different at speeds exceeding 100 mph.

POWER PLANT

The power plant for this train consists of a distillate-burning engine, developed especially for this service. It is of the

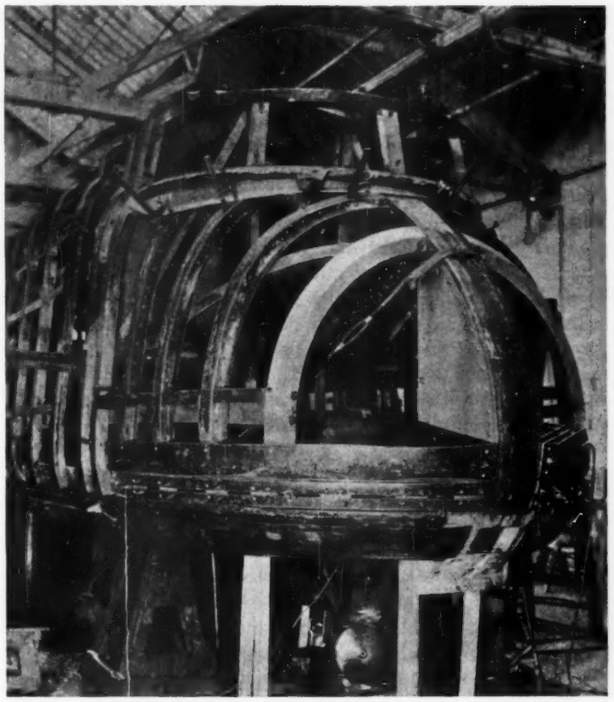

FIG. 5 FRAMING OF THE FRONT END OF THE TRAIN

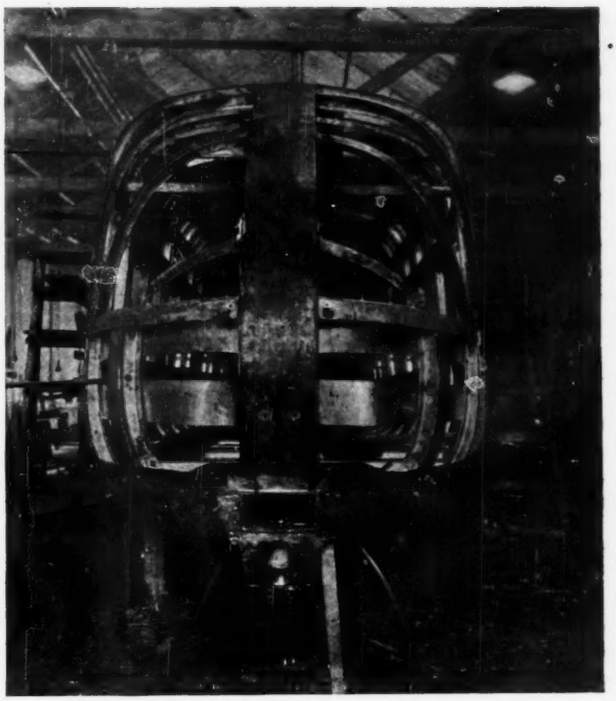

FIG. 6 FRAMING OF THE END OF THE TRAIN

twelve-cylinder "V" type, with cylinders 7½ in. in diameter and 8½ in. stroke, rated at 600 hp at 1200 rpm. The entire engine frame, including the crankcase and cylinder water jackets, is of welded wrought-steel construction. The crankshaft, 5½ in. in diameter, which is dynamically and statically balanced, is made of chrome-nickel-molybdenum steel, having an elastic limit of 130,000 lb per sq in., with a Brinell hardness of 300. No cast iron is used in the construction of this engine, except for the cylinder sleeves, which are made of a special grade of cast iron suitable for this purpose.

The distillate fuel is handled by special-type carbureters of the multiple-jet fixed-air-ratio type, which have been developed over a period of eighteen years, and are especially adapted to handling this heavy fuel. There is a separate carbureter having ten jets, attached directly to each cylinder head, and atomization of the fuel is accomplished without the application of heat. The fuel is supplied to the carbureter by electrically driven turbine pumps with gravity return to the fuel tank, and as floats and needle valves are not used, no surplus fuel is carried in the engine room. Fuel capacity is sufficient for a 1200-mile run.

To facilitate streamlining further, the cooling radiators are located under the ceiling of the engine room, and cooling is effected by having a closed engine room under forced draft. This also supercharges the engine to some slight extent.

The motorman, with all of his controls and necessary instruments, is located in an elevated cab separated from the main engine room. From his elevated position he will have an increased visual range, and be removed from the noise of the power plant. His main operating controls consist of a throttle, a controller, and a brake valve. The brake valve is equipped with a "deadman's" control, requiring a motorman to keep either a hand or a foot on this control while the train is running, and if, for any reason, hand or foot is removed from this control, there is an immediate automatic closing of the throttle and application of brakes. The direct-connected generator is connected to the front end of the engine by means of a flexible coupling and is capable of developing approximately 425 kw, and the current, through remote control, is led directly to the two 300-hp traction motors on the front truck.

In addition to the main generator, there is an engine-driven auxiliary generator having a capacity of 25 kw at 76 volts, which supplies current for battery charging, one of the two air compressors, air conditioning, and lighting. An additional 8-kw engine-generator set at 76 volts is carried in the baggage compartment for service when the main power plant is shut down.

AIR BRAKES

The air brakes for this train presented an important problem. In order to avoid rearranging the signaling system and also to avoid any additional operating hazard, it was necessary to be able to stop this train from 100 mph within the same distance that a conventional steam train could be stopped from the ordinary speeds at which they operate.

Heretofore, uniform braking retardation has not been possible, due to the fact that the coefficient of friction between brake shoe and wheels varies with the speed through a wide range, this coefficient decreasing rapidly at the higher speeds. In order to provide a uniform rate of retardation, it is necessary to control brake-shoe pressure automatically in proportion to the speed. In the new brake this is done by controlling cylinder pressure automatically by a very simple but effective device recently developed and thoroughly tried out, known as a "decelerometer." This instrument consists essentially of a movable weight of about 100 lb, sensitively mounted on ball-bearing rollers, arranged to move in the line of motion of the train, and suitably restrained by a calibrated spring. This weight, acting through suitable leverage and a pneumatic valve, controls the brake-cylinder pressure accurately in proportion to its inertia, and, therefore, in proportion to the retardation of the train. Recent tests with this device on a gas-

electric motor car developed a straight-line retardation graph from 76 mph to rest. Thus, by taking advantage of a simple natural law, it becomes possible to regulate brake-shoe pressure automatically in proportion to retardation and secure the maximum results in quick stopping.

If high rates of deceleration are used, it would be obvious that this device would control such deceleration up to a point at which the vehicle comes to rest, and by so doing, the sudden change from the high deceleration rate to a state of rest would result in a noticeable jolt at the end of the stop. In order to eliminate this, the decelerometer is provided with an ingenious valve device which changes the rate of deceleration to a low value just previous to the stopping of the vehicle. This results in a sudden final reduction in cylinder pressure to prolong the smoothness of deceleration to the end of the stop.

By the use of the decelerometer control, it is possible to insure stopping distances from exceptionally high speeds shorter than are obtained on steam trains running at much lower speeds, and without the slightest discomfort to the passengers, at the same time providing insurance against slid flat wheels.

The air brake used on this train is a complete departure from conventional practise, both in its circuit and in the design of the various valves and parts used. The pneumatic feature is based on a two-pipe circuit consisting of a supervisory line and a control line. The supervisory line distributes the air to the reservoirs under each car and charges to the maximum pressure at all times. In conventional brakes it is not possible to charge the reservoirs during brake application. The purpose of the control line is to apply and release the brakes by admitting air to the pneumatic relay valve under each car, this valve controlling communication between each brake cylinder and its adjacent reservoir, and from the cylinder to the atmosphere. This control line passes from the engineer's brake valve through the decelerometer valve to the relay valve. This briefly describes the pneumatic operation. Parallel to this pneumatic circuit lies an electric circuit actuated by contact points on the engineer's brake valve, which operates a magnetic control feature on each pneumatic relay valve. This not only synchronizes but accelerates all brake applications and releases.

The use of a straight-air brake system demands adequate protection against operating failures in case of pipe rupture or other unforeseen causes. To overcome this the relay valve units are constructed so as to insure proper operation upon the depletion of pressure from both the supervisory and control lines. If the electric circuits should fail from broken lines or other cause, the pneumatic elements in the system will function in the usual manner to supply adequate braking power.

All brake cylinders are of aluminum and are mounted on the trucks, two cylinders per truck, and each cylinder acts on one pair of wheels only. The front or motor truck has clasp brakes (two shoes per wheel) which are necessary properly to control brake-shoe pressures. The other trucks require only one shoe per wheel due to extremely small shoe pressures. All levers, beams, and other brake rigging are of aluminum to save weight.

AIR CONDITIONING AND VENTILATING

There is a duct on each side of the train below the floor line, and also a central ceiling duct, all of which are connected between cars by flexible bellows. Heat is obtained by passing air through the radiators of the engine. This air is forced by blowers through the floor ducts, a radiator outlet being located at each seat. Air is exhausted through a corresponding opening in the ceiling duct so that a definite circulation is obtained at each seat unit. An oil-fired hot-air furnace is installed in the baggage compartment and is capable of heating the train under all conditions should there be a failure of the heat from the engine radiator. It also provides heat for the cars at terminals or in the yards when the engine may not be operating.

A compressor is installed in the baggage room for cooling the air when desirable. For cooling, the circulation is reversed, cold air being discharged from the ceiling duct and exhausted through the floor ducts. In connection with both heating and cooling, approximately 25 per cent of fresh air is introduced in order to obtain frequent air changes and to keep a pressure in the car at all times for the exclusion of dust and cinders. The windows of safety plate glass are sealed in rubber and are set as nearly flush with the outside as practicable in order to minimize wind resistance. Two inches of a special fireproof insulation material is installed completely around the shell of the car and in the ends. This will give an unusual amount of insulation against heat and cold and also has special sound-deadening qualities.

LIGHTING AND SEATING

Careful study was made of lighting. Indirect lighting, from a trough on each side of the ceiling duct, was adopted. The light from this trough is reflected on each side against a properly curved ceiling cove in order to distribute it evenly at the reading position. The lights are so arranged that three intensities of light can be obtained, the lowest intensity being for night lighting while passengers are sleeping.

Seats were specially designed for this equipment, the object being to secure the maximum of comfort together with style and attractiveness. The space beneath the seats was kept clear to permit storage of baggage. The seat backs are adjustable with four positions. Seats are equipped with devices for the quick installation of an individual tray at the proper location for serving meals from the buffet.

OTHER FEATURES

The side doors when closed are flush with the exterior, and are interlocked with steps which fold up and down as doors are closed or opened, a flush trap-door inside of the car completing this assembly.

Electric signals afford communication between train crew and motorman. A powerful headlight of special construction is streamlined into the roof of the motorman's cab, and this headlight is provided with a 10-in. vertical light beam in addition to the horizontal beam, for the purpose of added safety. A powerful siren with long audibility range will be used for high speeds, supplemented by the usual type of siren for use through towns, yards, etc.

INTERIOR DECORATION

The interior treatment is simple but modern. The general color scheme is blue, shading from a nearly white ceiling by progressively darker shades of blue to the floor, metallic colors being used. Different shades of color are separated by horizontal aluminum moldings. The window sills are of black bakelite. The curtain rollers are entirely concealed and the curtains are of Venetian-blind design. The seat upholstering is golden brown and seats have aluminum trimmings. The floor is of cork tile with a harmonious carpet aisle strip.

GENERAL

It will be noted that the fundamental objective was to produce a high-speed train which would have a low operating cost, and in addition, give the passengers safety, quietness, smooth riding, comfortable temperature, and fresh air, all of which, it is hoped and believed, will help in attracting passenger business back to the rails from other means of transportation.

Interchanging

STEAM *and* Electric POWER

Cooperation Between Industrial and Public-Utility Companies in Generating Steam and Electricity

By H. DRAKE HARKINS[1]

PUBLIC-UTILITY systems in the United States (those having an annual output exceeding 100,000,000 kwhr each during 1932) have an installed generating capacity of 30,700,000 kw, 22,000,000 being steam and 8,700,000 being hydro (1).[2]

Manufacturing plants in 1929 had an installed generating capacity of 7,800,000 kw divided among 17,270 generators averaging about 450 kw each (2). Mines and quarries had 740,000 kw (3) installed in electric generators, bringing the total in industrial plants to 8,540,000 kw. The installed capacity of industrial plants is, therefore, approximately 27.8 per cent of the installed capacity of the larger public-utility systems.

Office buildings, hotels, hospitals, schools and colleges, and the like are not tabulated as manufacturers in the census, but for the purpose of this paper they could be included as industrial plants if the figures were available. Therefore, it is probable that the 27.8 percentage of installed capacity is approximately correct even though the very small utilities are not included.

The generating capacity actually installed in industrial plants is only that which management (unfamiliar with power problems) has seen fit to install with economic conditions as they now are and in the face of strong public-utility sales pressure.

Glenn B. Warren (4) states: "An estimate recently made showed that if all the industrial back-pressure and bleeder turbines manufactured in each of the years 1927 to 1929, inclusive, had been built for 1200 lb initial pressure instead of the 200 to 400 lb pressure for which they were built and arranged to supply the same heat, these turbines would have had an aggregate capacity over and above what they did have equivalent to about one-fifth of all the condensing turbines manufactured in the respective years. Similarly, an extension of this investigation indicated that if all these turbines which were installed to supply heating steam had been of the mercury-vapor-process type and, as before, arranged to supply the same demand for heat, these installations would have had an aggregate capacity over and above what they did have equivalent to almost one-half of that of all the condensing turbines manufactured in the respective years."

The author recently reviewed a proposed electrolytic process which involved the distillation of large quantities of mercury. The mercury vapor could generate twice as much electricity, 12,000 kw, as the electrolytic process required. The industry had no use for the surplus electricity and it could not be credited to the operation. In this instance, the absence of a market for surplus electrical energy hindered industrial progress and technical development.

Table 1, by A. R. Smith (5), shows how an industrial steam flow of 400,000 lb per hr at 200 lb pressure could generate no surplus energy, yet 42,000 kw were obtainable through present technology.

TABLE 1 STEAM FLOW TO INDUSTRIAL—400,000 LB PER HR

Initial steam conditions[a]	Entering evaporator[a]	Exhaust-steam conditions[a]	Electric power
200 lb, 525 F	No evaporator	200 lb, 525 F	None
400 lb, 750 F	No evaporator	200 lb, 625 F	5,970 kw
600 lb, 750 F	400 lb, 670 F	200 lb, sat.	5,150 kw
1200 lb, 750 F	400 lb, 518 F	200 lb, sat.	13,750 kw
2400 lb, 1000 F	400 lb, 618 F	200 lb, sat.	24,050 kw
125 lb mercury	28 in. hg vacuum to 400 lb steam	200 lb, 625 F	42,200 kw

[a] Pressures in lb per sq in. gage.

Therefore, it may be concluded that the present capacity installed in industrial plants is by no means a measure of what might justifiably be installed if an outlet were given for surplus energy, if full economic advantage were taken of technical development as shown in Table 1, if industrial management were educated in the economics of power generation, and if the utilities would accept the industrial plant as a possible source of cheap energy. It is obvious that these new conditions would result in a large increase in industrial capacity, mostly available for generating surplus energy. With industrial capacity now 28 per cent of utility capacity, it is equally obvious that any large increase in industrial capacity is of such magnitude as to satisfy the nation's demand curve for some considerable future period and leads us to the startling conclusion that the larger part of future electrical generating capacity should very probably be installed in or near industrial plants rather than in condensing-steam or hydro central stations. The superior efficiency of industrial "back-pressure" generation and its economic justification are well known to engineers and are shown elsewhere in this paper.

The public-utility systems are generally interconnected into a few great regional power pools, giving them the advantage of emergency supply, diversity, and reduction in spare equipment. Very few of the industrial generating plants are so interconnected either with each other or with the regional system. Many of the industrial plants generate electrical energy and utilize the exhaust heat from the turbine resulting

[1] Industrial Engineer, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del. Mem. A.S.M.E.

[2] Numbers in parentheses refer to bibliography at end of paper.

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in a production of electrical energy with much higher thermal efficiency (80 per cent) than can be obtained in utility steam stations (25 to 30 per cent). The seasonal heating load of many industrial plants enables them to produce a surplus of electrical energy above the plant requirement and at very low cost during the peak of the heating season, which is approximately coincident with the load peak on the utility systems.

Alfred W. Fox works out a specific case (6) for providing the top 20,000 kw of an actual public-utility load-duration curve which contained 867,000 kwhr. If a new central station is provided, the annual costs are $262,000 for a peak load steam plant, $229,000 for a base-load steam plant, $255,000 for a hydraulic peak-load plant, and $257,000 for a steam-accumulator plant. An industrial plant having or needing the boiler capacity can provide the 20,000 kw in generating capacity and the energy at an annual cost of $171,000. This is an annual saving of $58,000. All costs are total, including fixed and operating charges. Mr. Fox concludes, "the figures used above may be open to question. I believe they are sufficiently accurate for a discussion of this nature and are moreover so variable as to require special attention and estimate on each particular problem. When times become normal, the peak-load problem of the public utility will again assume its previous importance, and I believe that solving the problem in conjunction with one of surplus power can mean a great saving to the utility and a source of additional profit to the industrial plant."

Many industrial power engineers believe the general refusal of the utilities to buy their available surplus energy is unsound national economics, unfair competition, and shortsighted policy. Guy B. Randall (7) also champions this opinion. They feel that such purchase or some interchange or other cooperative agreement will economically justify the installation of a great many more industrial power plants with a reduction in their own and the nation's power bills. These industrial engineers point out that most hydro stations and a great many utility steam stations are necessarily located remotely from the load center, requiring expensive, elaborate, and hazardous transmission systems which contribute to the result that the delivered cost of electricity to the ultimate consumer is from two to twenty times the cost at the generating station. (This spread should not irritate industrial plant engineers who pay two-dollar freight on twenty-cent coal, but should be accepted as economic fact.) A great many of the industrial plants are very near other consumers where industrial-plant surplus energy, lower in generating cost, could be delivered with small transmission loss to their neighbors if the utility transmission system were opened to the industrials.

The advantage of interconnection and other advantages of interchange with industrial plants have been ably pointed out by B. F. Wood (8). W. F. Ryan, a thorough student of this subject, outlines the advantage of cooperation and other industrial opportunities in his paper (9). W. S. Monroe has emphasized the importance of by-product power generation and pointed out the necessity for cooperation between utility and industrial companies (10).

Utility companies generally refuse this industrial-plant energy and other cooperative schemes for the following reasons (11):

(1) Possibility of having to face the charge of discrimination in cases where the utility chooses to make a working arrangement with one industrial and to deny it to another.

(2) Hazards to service presented by a number of small, isolated plants whose engineering and operating standard may be below the utility grade.

(3) Complications of supplying process steam non-electrical service to industrials.

(4) Financial hazards and disagreements potential in joint ownership and operation of utility and industrial plant equipment.

(5) Danger of increasing industrial business to an unsafe volume in proportion to total business.

(6) Objection to committing utility funds to investment in power facilities in industrial plants of uncertain business continuity.

(7) Possibility that an industrial plant with excess capacity will attempt to sell this directly to users at a higher profit than the interchange rate permits.

(8) Variations in efficiency of industrial plants delivering by-product electricity as a function of blast or other process heat usage.

(9) Inflexibility of such by-product plants as compared with utility generating stations.

But at least one utility executive (12) recognized the importance of power interchange and its benefit to the whole community, pointing out that it is the industrial plant's payroll which supports the utility and it is the utility's service which improves living conditions for the industrial's workmen. Cooperation between the two, he concluded, has a broad economic and sociological foundation.

Much of the difficulty in reaching a cooperative agreement for the mutual sale or interchange of electrical energy between utility and industrial companies lies in the misunderstanding of the value of a unit of energy. The value varies widely if it be "firm or dump," with the time of the day and year, and with the installed capacity of each party at the instant of generation. W. B. Skinkle has admirably and thoroughly expounded the fundamental principles in his papers on this subject (13, 14, 15). (These three papers are recommended to every engineer contemplating or negotiating a cooperative power contract.) Especially pertinent to the subject of this paper are Figs. 1 and 2 reproduced from Mr. Skinkle's discussion (13). Fig. 1 illustrates how the large generating units of a public-utility system increase capacity in steps, making the capacity growth very unlike the more uniform growth of the load curve. Fig. 2 illustrates how industrials and utilities may both delay investment and avoid installations of capacity far beyond requirement by a mutual and cooperative exchange of power. These curves refer principally to large-capacity industrial installations. It would be interesting to see the result if some utility system endeavored to provide for the gradual growth of its load by an equally gradual utilization of surplus power from industrial plants. The inspiration for such an attempt must come from the management or engineering groups of the utility company. At present, contact between utility and industrial is usually made by the power-sales division of the utility which, naturally enough, is only interested in selling energy and is not interested in the economic or engineering aspects of the power problem as a whole.

We hear much, especially from political sources, of the undeveloped hydro energy available in this country. Undeveloped hydro becomes more and more remote and it has already been pointed out that transmission costs now exceed energy-conversion cost. The public has heard very little in this country concerning the use of this great quantity of cheap industrial surplus electrical energy which is now available in the very heart of our consuming districts.

The power utility is given a monopoly on the assumption that it will serve the community more efficiently than any other means yet devised. Therefore, it is obligated to investigate sources and secure cheap energy, either by purchase or genera-

tion, and to distribute energy cheaply and efficiently. It is not unreasonable to ask these companies to purchase surplus industrial energy, if such purchase will benefit the community by fostering local industries and reducing the utility cost. Certainly this conception of the utility does not justify the intense and extravagant effort sometimes made to prevent industrial generation. Many individual utility companies are, in fact, only distributors, owning no active generating equipment and buying from affiliates. These distributors may well be asked to purchase industrial energy at a price commensurate with that they now pay.

This whole proposition is naturally so involved, technically and economically, that we can find a solution only through study and experiment made with greatest honesty and caution. So involved is each problem that the smoke-screen of confusion is ever at the disposal of partizans. So technical is each problem, that all but the engineer are lost. Industrial managers are confused alike by equipment and power salesmen. This is a task for the most capable industrial and utility engineers.

While cooperation between utilities and industrial plants has no existence on a national scale, there are some isolated

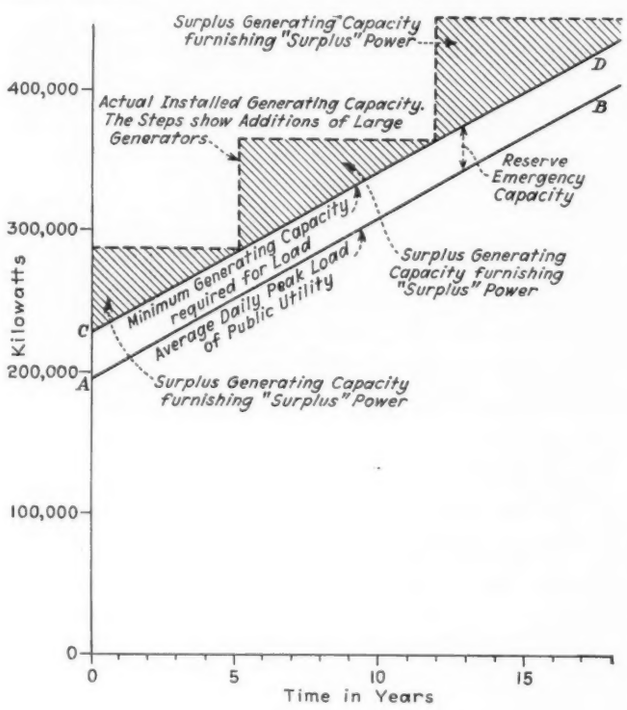

FIG. 1

instances, and it is the object of this paper to examine such cases as exist, review the contractual and physical arrangements, and evaluate the success, in the hope that this study may assist progress in cooperation between utility systems and industrial plants.

EXAMPLES OF COOPERATION ABROAD

In England, the Electricity Act of 1926 created a governing board to integrate public-utility generating systems. This Act provides for current to be fed into the "grid" from industrial plants and gives power to the Electricity Board to purchase surplus electricity in such cases. A British correspondent (16) stated in April, 1933, that at that moment there was no actual case from which he could obtain any particulars but gave as a reason that it was only recently that the grid has been put into actual operation and it is not yet complete. He believes that industrial cooperative schemes have been left over until the distribution of supply is more completely organized and the unification of frequencies achieved.

A prominent American engineer (17) states:

> The Belgium state has organized a corporation on which manufacturers, users, engineers, and the government are represented in the directorate to connect up all of the power plants, both utility and industrial, in the eastern half of Belgium. This corporation is known as the Union Générale Belge d'Électricité and has been running now for about five years. The arrangements have been most satisfactory, I understand, to all users and manufacturers, and the profits, while they have not been large, have been substantial and of sufficient amount to insure the continuation of the corporation. . . .
>
> The western part of Belgium is handled by Les Centrales des Flandres with headquarters at Ghent, while another public-service company operates Brussels and the surrounding territory. It is intended that in the end the whole of Belgium will be tied-in in one generating and operating company, but this will probably be sometime in the future.

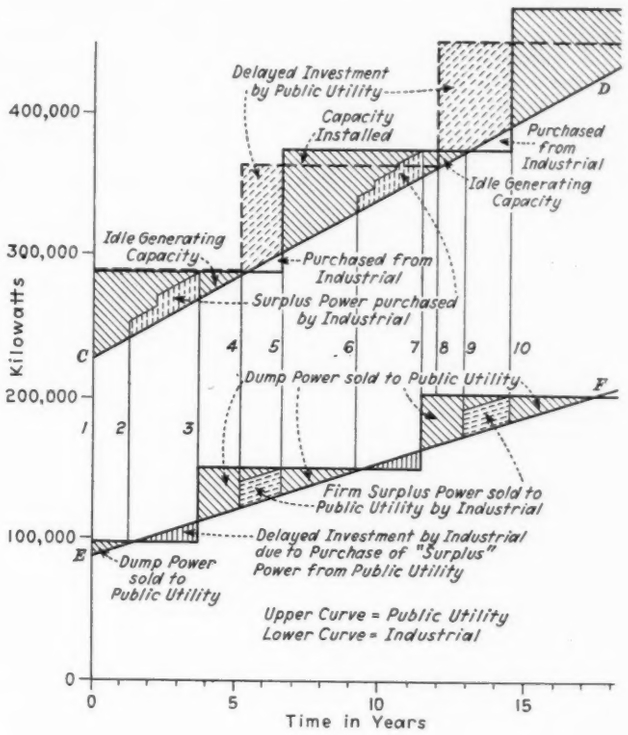

FIG. 2

While not of national importance, a regional cooperative arrangement of great interest and significance was consummated at Sydney, Nova Scotia. Here is a case where the power corporation and several industrial companies and a municipal lighting plant cooperated, with the approval of the Board of Public Utilities, with a result that has been satisfactory as regards service, economy, and earnings. Steel plant and mine operations are scheduled in such a way that the power corporation can provide necessary power at a minimum of cost. The effect of a proper rate schedule on power demand and usage at coal mines and steel plant has been extraordinary and has resulted in substantial economies for these industrial concerns. Refuse coals and coke breeze are used for generating electricity and domestic current usage tends to increase due to

reduced rates. K. H. Marsh (18) has provided data for 1929 in Table 2. He says:

TABLE 2 STATISTICS OF POWER GENERATION AT SYDNEY, N. S., 1929

Generating station	Kw installed	Frequency, cycles	Annual output, kwhr, in millions	Fuel
Steel Co., station No. 1	11,500	60	45	Blast-furnace gas, coke breeze, and coal
D. Coal Co., station No. 2	7,000	25	41	Slack coal, stoker-fired
D. Coal Co., station No. 3	4,000	25	15	Slack coal, stoker-fired
S. Coal Co., station No. 4	2,400	60	11	Slack coal, hand-fired
Utility Co., station No. 5	1,000	60	4	Slack coal, hand-fired
Municipal, station No. 6	400	60	1	Slack coal, hand-fired
Total			120	

The above plants [Table 2] are listed in order of efficiency. With more normal industrial activity all stations were overloaded at times.

Stations No. 2 and No. 3 (25 cycle) were tied together electrically.

Stations No. 1 and No. 5 exchanged stand-by service.

Stations No. 4 and No. 6 assisted each other at times.

Now in 1930, a power corporation was formed and put into operation a modern 7500-kw steam-electric generating plant, which was interconnected with Stations Nos. 1, 2, 3, 4, 5, and 6. A 25–60-cycle reversible frequency changer was installed, and a program of colliery electrification was completed. The power corporation leased Stations Nos. 1, 2, and 3. Stations Nos. 4, 5, and 6 were closed down.

The power corporation put into effect a schedule of rates approved by the Board of Public Utilities, and operates its very efficient modern station on base load, while Stations Nos. 1, 2, and 3 operate to suit the load from steel plant, coal mines, utility company, municipal lighting, as well as lighting for several small mining villages.

There are other instances in Canada where large industrial plants provide steam-electric stand-by service to promote good-will in communities where small hydro utilities could ill afford to provide their own steam stand-by. And the hydroelectric utility assists the industrial steam plants at certain times. There are cases where hydro installations with unused capacity sell electrical energy to industrials for use in steam boilers at little more than fuel cost, but, of course, on short-term contracts.

EXAMPLES IN THE UNITED STATES—PARALLEL OPERATION

The simplest case of cooperation between utility and industrial in the generation of electrical energy occurs when the industrial secures part of its demand from the utility and operates its own generating equipment in parallel with the utility but does not feed back. So many installations of this kind exist in the United States that it may be called common practise, although a few utilities have earned the ill will of their customers by refusing to cooperate to this extent. This attitude is untenable, as can be proved by the entire success of the numerous existing installations. The utility in one large Eastern city states that it has twelve customers operating in parallel, the largest taking 6500 kw from the power company and the smallest 100 kw. All have contracts of three years' initial duration which continue from year to year with a 60-day cancelation clause. In none of these cases is there any pump-back of power into the utility lines and the power purchased is taken in each case under a standard form of contract.

There is an unusual case of parallel operation in an Eastern seaboard city where an existing industrial plant which generated all its own steam and electricity had an opportunity to sell steam to a new industrial located on adjoining property. The first industrial had sufficient installed capacity to supply its neighbor with both high- and low-pressure steam. The low-pressure steam could be extracted from one of the turbo-generators, but this extracted steam would only generate part of the neighbor's requirement. The local utility might possibly have blocked this sale of electricity because of existing laws, but generously cooperated and sold electrical energy to the first industrial for resale to the neighbor in accordance with the demand. All of the three parties profited. The utility gained by selling some energy and also succeeded in running its service lines into the plant of the first industrial which had never before been connected with the utility. The first industrial profited by the sale of steam and electricity without the necessity of increasing its installed capacity to meet the new load. The newly located industrial obtained steam and electricity at a cost lower than could have been obtained by building its own power plant and/or purchasing electricity from the utility. This arrangement has been in operation several years and has been entirely satisfactory to all of the three parties.

Many additional installations for parallel operation would be made economically attractive were it not for the additional financial burden imposed by the necessity for the industrial company to install spare generating equipment or pay a burdensome demand charge because of the periods when its one generator would be out of service. In a few instances, cooperatively minded utility companies have waived the demand charge on the grounds that the unusual demand was caused by an unavoidable breakdown. Modern central-station generating equipment has an availability better than 90 per cent and industrial turbo-generators without condensers probably have a higher availability. Industrial plants having normal week-end and annual inventory shut-downs can depend on emergency shut-downs occurring less frequently than yearly. Nevertheless, an industrial power engineer must conservatively include the maximum possible annual demand charge when preparing his project for the installation of a single turbo-generator and this prevents the authorization of many.

Utilities defend this high demand charge by maintaining that the business is unattractive and that generating and transmission capacity must be provided for the ultimate unavoidable breakdown. This contention is, undoubtedly, sound when considering a single installation or an isolated industrial at the end of a long transmission line, but if industrials which are located within a reasonable distance of each other were permitted to feed back their surplus energy into the utility system, the statistical effect, diversity, load factor, etc., would probably result in placing no additional burden on the utility's generating equipment by infrequent individual breakdowns and would require but very little additional transmission capacity.

An example of prohibitive demand charge existed in an industrial plant which generated all its energy but had a public-utility connection of some 300 kw demand for use in starting a cold plant after a total shut-down. The demand charge included some energy which was completely used. After two years' experience, the industrial secured a handsome return on an investment which was made for the installation of a 300-kw gasoline set. The service connection from the utility was discontinued.

A large utility which has numerous customers in parallel operation but none feeding back states that its company policy is an exceedingly broad one in dealing with special conditions and if, at a future time, conditions might arise wherein it would be advisable and profitable to both the customer and

the company to draw up a form of contract wherein any power would flow both ways, it is sure the company would give this serious consideration.

INDUSTRIALS WHICH SELL ENERGY TO UTILITIES

This subject is so shrouded in secrecy that no quantitative data can be secured or given. The issue of a magazine (19) devoted to this subject lists the following:

(1) Northern Paper Mills at Green Bay, Wis., developed two hydro sites with capacity over its requirement for sale to the Wisconsin-Michigan Power Co.

(2) Newton Falls Paper Company sells surplus hydro to Northern New York Utilities.

(3) The Wauregan Mills, Wauregan, Conn., sells surplus hydro up to 1000 kw and purchases power deficiency up to 300 kw.

(4) North American Cement Corporation, Security, Md., generates from waste heat and sells to the Potomac-Edison Co.

(5) The Colorado Portland Cement Company, Boettcher, Col., sells surplus electricity generated from waste heat to the local utility.

(6) The Manitowac Plant of Medusa Portland Cement Company interchanges power with the Wisconsin Public Service Company, using waste heat to generate surplus energy.

(7) A woodworking plant in New Hampshire uses refuse to generate surplus energy for sale to the Twin States Gas and Electric Co.

(8) The Commerce Royalty and Mining Company, Cardin, Okla., operates a Diesel plant which supplies 18 lead and zinc mines, also the Northeast Oklahoma Railway in the city of Miami.

(9) The Sapphire Cotton Mills, Brevord, N. C., sells energy over the week-end to the local utility.

(10) The Fairbanks-Morse test floor sells surplus energy to the local utility.

(11) The University of Michigan sells surplus energy to the Detroit Edison Company during the heating season and purchases in summer.

(12) In Pittsfield, Mass., the electric company buys surplus energy from a large textile and dye works and sells stand-by.

(13) The Twin City Plant of the Ford Motor Company operates a hydro station which was built under the government requirement that all available hydro be generated. The surplus energy is sold to Northern States Power Company. The government gets free power for lock operation.

An interesting aspect of the last case quoted is the governmental requirement that surplus available energy be diverted into useful channels.

An industrial plant in Virginia generates all its own power and sells power to the utility for use in two near-by industrial plants during times of utility power failure. This cooperation by the industrial plant prevented the utility from losing two customers who would otherwise have built their own plants to secure continuity of service.

The Eli Lilly Company at its Indianapolis Laboratories purchases steam from the Indianapolis Power and Light Company, generates electricity with this steam, and sells the electricity to the power company. The electrical demands of the Eli Lilly Company are satisfied from the lines of the power company (20).

The Crocker-Burbank Company, of Fitchburg, Mass., sells surplus by-product power to the local utility (21).

A large motor company believed in 1931 that its power-plant loads had dropped to the point where it would be advantageous to purchase some current on week-ends and holidays and, accordingly, entered into an interchange agreement with the local electric company. This contract carries no demand charge and calls for an interchange of energy at a straight energy charge. Neither party guarantees to furnish the other power at any particular time and each party is the sole judge of its ability to serve. While this rate is classed as an interchange rate, the electric company has never permitted the motor company to deliver any power to it under the terms of the contract and in effect it is a straight energy contract without any demand charge. The contract may be classed as a failure, and one of the industrial company's officials states, "It has been my experience that there is not sufficient genuine cooperation between the utility and the industrial to result in the most advantageous mutual arrangements. The industrial plant is too often viewed as a competitor of the utility which the utility must endeavor to eliminate. This attitude is sure to interfere with entering into those contractual relations which would contribute most to the benefit of both parties."

For some years prior to the construction of its new central station, an Eastern utility bought energy from a large industrial which was so located on the utility's system that it could supply energy to great advantage during peak loads and when transmission troubles occurred. This was a straight sale of firm power subject to the call of the utility's dispatcher. This is an example of the utility's using available industrial capacity as exhibited in Fig. 2.

A utility has an interconnection with a large industrial company for the exchange of electric power. The interconnection consists of two banks of transformers rated at 30,000 kva each. Both banks are owned by the utility but the industrial is billed for the rental of the second bank. There is no formal contract covering the exchange of power. A letter, accepted by both parties, fixes the charge per kilowatthour of net exchange. There is, ordinarily, no such net exchange. During the reconstruction of the industrial's power house, a considerable supply of energy went to the industrial at a fixed price. On occasion, during tests, etc., the industrial has returned power to the utility but at a special rate much lower than fixed in the letter. Both parties stand ready to pick up loads in the event of an emergency and such an emergency has occurred two or three times. The utility states that the interconnection has been most useful. The arrangement may be terminated at any time by mutual agreement.

An industrial in an Eastern city has an installed capacity of 1250 kw with a day load steadily over 1000 kw and with occasional 1300-kw peaks. The plant is connected with the utility, and more than ten years ago made a cooperative agreement for exchange at $3\frac{1}{2}$ cents per kwhr and without demand charge. The exchange of power was nearly even and considered fair by both concerns. This agreement survived one change in ownership of the utility. After a larger holding company had taken over the local utility, it made many different propositions for supplying all the industrial's energy, but none was found acceptable. Two years ago the utility reduced the exchange rate to $1\frac{1}{2}$ cents and stopped taking energy from the industrial. One year ago the utility abrogated the exchange rate and put the industrial under a standard service classification. This increased the industrial's rate to 5.3 cents per kwhr. The industrial complains because its demand charge is figured from the maximum setting of its transformer switch. This, it feels, is unfair, and if not changed will force the industrial to build its own stand-by. Its own service had always been dependable. This switch must be set well above the actual demand because when set close to the

demand the industrial lost its load several times while running in parallel with the utility. The industrial's engineer states: "During the winter months when exhaust steam is needed, operation is such that the utility cannot expect to compete, but during the summer months when our loads are so high that we waste exhaust steam it is just too bad that the power company cannot compete with such methods."

LARGE-SCALE OPERATIONS

Although utility companies have been reluctant to make cooperative agreements with smaller industrial plants, several large-scale operations exist in the United States where advantage has been taken of industrial waste heat and fuel or of industrial demand for large quantities of steam; thus giving opportunity for the cheap generation of electrical energy.

The Deepwater Station, located on the New Jersey side of the Delaware River some 30 miles below Philadelphia, is an outstanding example and has been adequately described in the technical press (22). This 1200-lb central station houses two condensing turbo-generators, each owned by a different utility, and also contains one turbo-generator which exhausts to evaporators. The evaporator vapor is delivered in quantity up to 400,000 lb per hr to an adjacent industrial plant. This is strictly a cooperative venture, although the industrial has no capital invested in the station. The industrial was about to build its own high-pressure plant when the utility contemplated a new station in the neighborhood, and one plant was built instead of two in the expectation of realizing the benefits which naturally accrue to a single large-scale operation. The station has been in service approximately three years and the entire operation has been successful. The contractual success is almost entirely due to the spirit of cooperation with which each party has settled unforeseen contingencies as they arose. Although the contract covered many pages and took upward of six months' careful negotiation to complete, it, nevertheless, did not foresee all possibilities, and if a spirit of cooperation had not existed among all contracting parties, ultimate failure might have occurred. Advantages to the utility have been a larger-scale operation and a high boiler load factor with consequent economies. The industrial has secured the benefit of skilled and efficient power-plant operation without burdening management with the responsibility. The disadvantages to the industrial were: First, the much longer construction period with consequent delay in achieving the economy of high-pressure operation. Second, there is not the flexibility in meeting changes in conditions which would exist if the industrial could operate entirely within its own organization and through its own procedure. The author is not in a position to state the disadvantages to the utility.

In 1929 the growth of load on a Southern utility system had reached the point where it was apparent that additional power supply facilities would be necessary. The ideal location for additional capacity was at the eastern terminus of the system which, as it so happened, was the location of an oil refinery. The refinery was planning extensions. A large generating station (technically not a utility) was built adjacent to the refinery. This station planned to supply the refinery with a maximum of 840,000 lb of steam per hr and 14,000 kw. The oil company could have built its own power plant and generated the electrical requirement with about 400 lb boiler pressure. By building for 625 lb pressure, a large surplus of electricity could be generated and is sold to the local utility. The refinery supplies several kinds of liquid refinery waste to be used as fuel in the power plant. Petroleum coke is delivered in railroad cars. Both parties had many vital interests to protect. The oil company was anxious to get the very best possible price for its non-merchantable but burnable waste fuels and to assure itself a continuity of service. The steam company needed guarantees for its investment and assurance of continued business, a very definite relation between the price at which it had to sell steam and electricity and the cost of fuel, and the ability to convert its plant to a normal type of condensing station should the contract with the oil company ever be terminated. As the situation developed, it became apparent that this contract could only be made on some mutual basis. Since the plant went into operation, an additional boiler has been installed to permit the sale of additional steam up to a total of about 1,000,000 lb per hr. The company which operates the plant is not a utility. It confines all its operations to its own property and its customers come to it with their pipe lines and electrical connections. It is so located that it is in a position to serve other customers at equitable rates, preferably those with needs for both steam and electricity. At present the entire requirements of the oil company and of one utility are well cared for, and the surplus energy is utilized by another utility.

A technical publication (22) states that the Iowa Railway and Light Corporation and the Quaker Oats Company at Cedar Rapids have an arrangement whereby the utility generates steam for the industrial and uses the industrial's waste fuel, oat hulls.

The same publication (22) states that the Rochester Gas and Electric Company supplies steam to several industrial plants and also heating steam to the business section and has 12,000 kw installed in non-condensing units.

Regional energy coordination in the Chicago district developed a unique cooperative arrangement between steel plants and electrical and gas utilities as described by A. H. Dyckerhoff (23). A very careful, extensive, and thorough survey of steel mills under all load conditions indicated that a saving of from $0.43 to $1.36 per ton of steel could be effected by selling coke-oven gas and purchasing electricity. This startling conclusion displaced the previously held opinion that steel mills should use all their available heat for metallurgical and power-generation purposes. An exchange of energy between steel plants and gas utilities has been worked out in the region of Chicago, linking six basic steel plants with electrical and gas utilities, resulting in purchasing electrical energy, selling coke-oven gas, and using blast-furnace gas for heating rather than for power generation.

The General Electric Company is building a mercury-vapor plant at Schenectady (5). Additional steam supply was needed and the New York Power and Light Corporation desired additional electric generating capacity, it being agreed that a steam plant erected at or near the Schenectady works could and would economically supply both. The General Electric Company constructed the plant on its own property, placed it strategically for steam distribution, and is leasing it to the power corporation which, in turn, operates and maintains the plant. The steam delivered to the Schenectady works at 225 lb pressure will amount to 630,000 lb per hr. The industrial provided the capital and constructed the plant, and the utility leases the plant on the basis of the fixed charges on the actual investment as a yearly rental. The utility admits that a plant having a capacity of 26,000 kw has for it a certain value per kilowatt of capacity, and the fixed charges on such investment are credited to the industrial. This amount is less than the rental, because the actual cost of the plant provided not only for the production of 26,000 kw, but 650,000 lb of steam also. The utility also allows a credit for each kilowatthour produced by the plant, all of which

goes into its system. This credit is based on the prevailing costs of producing power with modern plants supplying its system, taking into account the fact that the utility must always accept the power produced according to the steam demand, regardless of the hour of the day or the season of the year. The utility sells all the power that the industrial demands at scheduled rates, regardless of this particular agreement; and the excess cost covering the rental, operation, and maintenance and the fuel over and above the two credits allowed the industrial is charged to the industrial as its cost of steam. The agreement between the two companies covering operation is in effect for five years; thereafter continuing from year to year unless terminated by either party on one year's written notice.

CONCLUSION

Modern technical developments in higher steam pressures and mercury-vapor cycles make available more and more surplus electrical energy from industrial steam flow, and this technical development favors the generation of electricity in connection with industrial processes.

The steam flow to industrial plants is of such magnitude and the industrial plants are so located that the larger part of future electrical generating capacity should very probably be installed in or near these industries rather than in new condensing steam or hydro central stations.

Cooperation between public utilities and industrial plants in the generation of steam and electrical energy will reduce generating cost and the investment in generating equipment, thus ultimately reducing the nation's power bill and resulting in the still wider dissemination and use of electrical energy, which is the basis of our industrial civilization.

An unsound economic condition in power generation is maintained by the utilities' competitive sales campaign.

Industrial management must be educated in the apparent paradox that small-scale "back-pressure" power generation is more efficient than the "quantity production" in condensing central stations.

A spirit of cooperation must be fostered by public-utility executives and engineers if industrial engineering antagonism is to be avoided and public relations improved.

A detailed survey of American conditions will probably prove, and the success of the Union Générale Belge d'Electricité indicates, that a program of cooperation will be successful.

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HEAT TRANSFER *in* MERCURY SYSTEMS

By W. T. MOORE[1]

HEAT transfer in mercury systems involves primarily evaporation and condensation. The low specific heat of liquid mercury practically eliminates the use of this material in the liquid form. The superheated vapor also has a low specific heat and its use is practically limited to overcoming pipe-line condensation.

Evaporation and condensation are, in general, less understood than other phases of heat transfer. The published data are relatively meager, and, due to lack of agreement as to the fundamental theory involved, they are more difficult to interpret and apply. In the case of mercury and its vapor, these difficulties are aggravated by certain peculiar characteristics of this material.

In considering evaporation, one ordinarily thinks in terms of liquids, such as water, which wet a metallic surface with which they are in contact. It is a well-known fact that liquid mercury at atmospheric temperatures does not wet a steel surface, unless special means are employed. However, this is no indication that the wetting phenomenon may not change under pressure and at high temperature. It is conceivable that mercury may wet ordinary steel tubes under certain conditions. The significance of wetting in the process of evaporation lies in the good contact obtained between the metal surface and a liquid film adhering to it. Heat flows readily from the metal surface into the liquid of the film. Vapor bubbles are formed, and under proper conditions of circulation, these bubbles break away and are replaced by more liquid. This new liquid in turn wets the surface and reforms a closely adhering liquid film, so that the process is repeated and a supply of liquid in contact with the metal is assured. With liquids which do not wet the surface, there is less positive contact between metal and liquid and less tendency for the vapor bubbles to break away from the surface and be replaced by liquid. Hence, the supply of liquid in contact with the metal surface is not so readily maintained.

Another interesting point is the effect of the high liquid density in producing different pressures at different levels in the boiler. Thus in a tube 5 ft high the pressure at the bottom of the tube may be 25 lb per sq in. higher than at the top. Because of the low specific heat of the liquid, the fluid tends to assume the boiling temperature corresponding to the local pressure. In a tube in the usual type of mercury boiler in which a liquid level is maintained in a drum at the top of the tube, liquid at saturation temperature corresponding to the pressure at the liquid level is introduced by recirculation to the bottom of the tube and thus arrives at the bottom of the tube at a temperature considerably lower than that corresponding to the pressure at the bottom of the tube. This relatively cool liquid introduced at the bottom of the tube must, of course, travel a certain distance along the length of the tube in order to absorb sufficient heat to bring it to the boiling temperature corresponding to the local pressure. The specific heat of liquid mercury is so low that this would generally be only a few inches. With a 5-ft tube at a pressure of 100 lb per sq in. gage, there is a difference of about 30 F in the boiling temperatures corresponding to the pressures at the bottom and the top of the tube. At lower pressures this difference is greater. Therefore, we can say, practically, that the mercury in the lower part of a 5-ft boiler tube would, in general, attain a temperature at least 25 F greater than that at the top.

Notwithstanding these difficulties, mercury boilers have been operated with heat inputs of 90,000 Btu per hr over a vertical tube having 3.5 to 4 sq ft heating surface located above a furnace having a temperature of 3000 F and with 925 F mercury vapor inside the tube. In ordinary practise the heat input is kept below this figure. Sufficient evidence is available to indicate quite definitely that with proper design, calorized carbon-steel tubes are satisfactory up to vapor temperatures in the neighborhood of 900 F with a corresponding pressure of about 80 lb per sq in. gage. Carbon-steel tubes uncalorized may be used for vapor temperatures up to about 750 F.

With regard to condensation, the vapor which touches the cold condensing surface is the vapor that is condensed, and the important point is to keep a fresh supply of vapor in contact with the surface and to remove the condensate from the surface as speedily as possible. At the beginning of a condensing process, only vapor is present, the resistance to heat transfer to the cold surface from the vapor is practically zero, and a high rate of heat transfer results. As condensation proceeds, there is a tendency for a film of condensate to collect. For some liquids this film may be fairly thick and may interpose considerable resistance, but this is not the case with mercury which does not wet the surface. Therefore, comparing mercury with other liquids, we would expect higher heat-transfer coefficients in condensation and lower in boiling.

Fig. 1 shows a mercury condenser which was operated in the Bayonne plant of The Babcock & Wilcox Co. in connection with experimental mercury boilers. This condenser consisted of three parallel tube coils containing condensing mercury vapor. These coils were contained in a vertical cylindrical shell in which water was evaporated by the condensing mercury. Mercury vapor passed through a throttle valve and then entered the coils at the top. Liquid mercury was withdrawn at the bottom. A water level was maintained in the shell. Water entered at the bottom of the shell below the level and superheated steam left at the top. The shell was 1 ft 8 in. inside diameter and 2 ft 9 in. high, and the coils contained 19.5 sq ft of surface in contact with mercury vapor. Fig. 1 and Table 1 contain further detailed information on dimensions.

The water level was purposely maintained in the lower part of the shell in order that the incoming hot mercury vapor might pass first through the low heat-transfer zone above the water level and lose some of its temperature before entering the high heat-transfer zone below the water level. This was done on account of experience with a previous mercury condenser where hot mercury vapor was brought directly into contact with tubes

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containing cold water, with the result that enormously high heat-transfer rates (in excess of 200,000 Btu per hr per sq ft) were obtained and tubes cracked due to temperature strains. The condenser shown in Fig. 1 was not built with the idea of obtaining heat-transfer rates, but was conservatively made in order to avoid excessive heat inputs. The heat-transfer rates obtained are, therefore, very far from the maximum obtainable.

Test data were obtained on this condenser for the following items:

Mercury vapor temperature before throttle valve

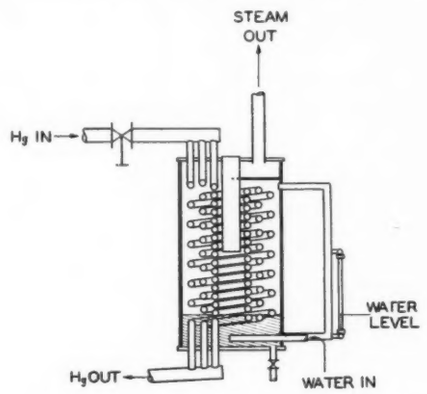


FIG. 1 MERCURY CONDENSER AT BAYONNE PLANT

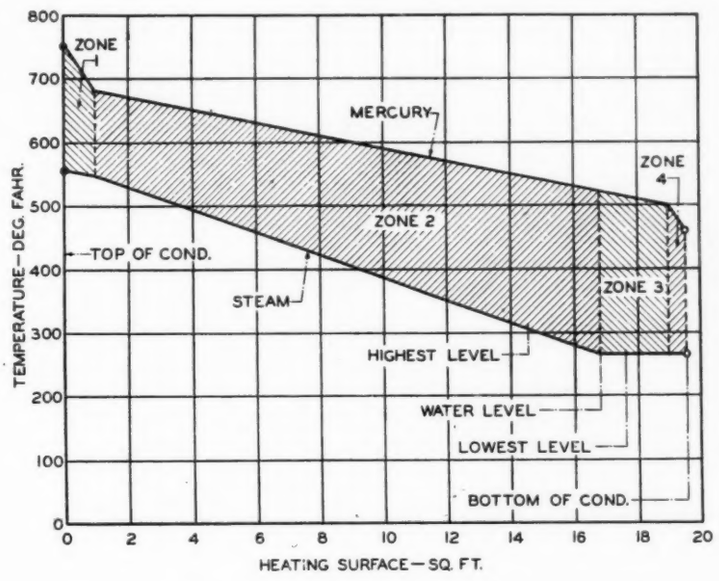


FIG. 2 TEMPERATURE CONDITIONS IN MERCURY CONDENSER

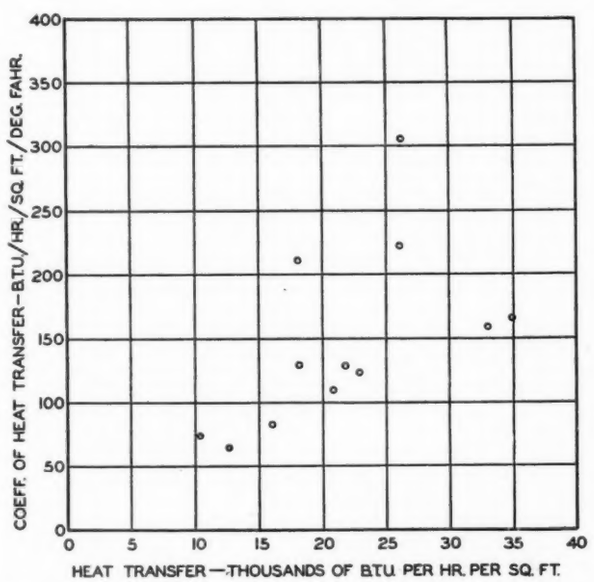


FIG. 3 COEFFICIENTS OF HEAT TRANSFER IN MERCURY CONDENSER

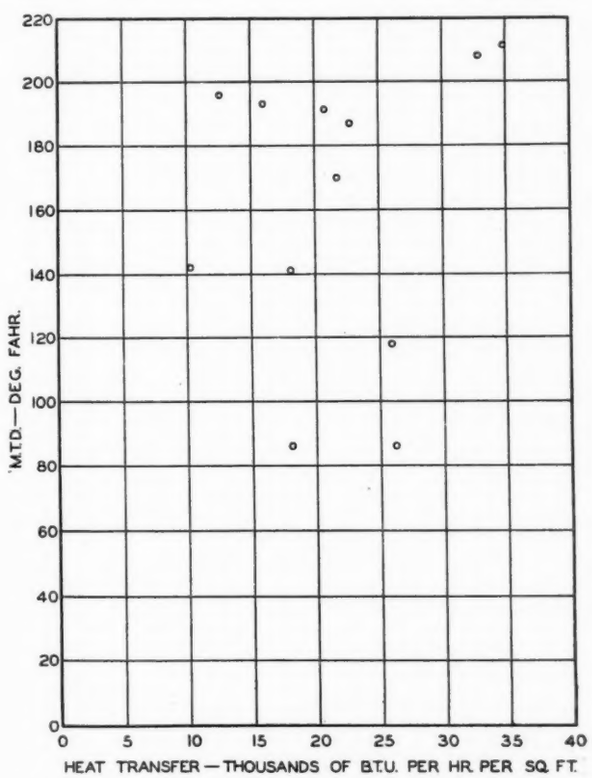


FIG. 4 MEAN TEMPERATURE DIFFERENCE, MERCURY CONDENSER

Mercury vapor temperature after throttle valve
Mercury liquid temperature leaving condenser
Water temperature entering shell
Steam temperature leaving shell
Steam pressure in shell
Weight of water evaporated.

Actual temperature conditions in the condenser may be represented qualitatively by Fig. 2. It seems reasonable to assume that the mercury vapor leaving the throttle valve is superheated. Inside the condenser the mercury vapor must first give up its superheat. During condensation the temperature falls rapidly with reduction in pressure due to friction loss After condensation, the liquid may or may not be cooled considerably below saturation temperature. On the water side, the steam above the water level is superheated as much as 481 F.

From a heat-transfer point of view, the apparatus should be considered in terms of three and possibly four zones as follows:

TABLE 1 TESTS ON MERCURY-VAPOR CONDENSER

(Three tubes, 1 in. extra-heavy seamless-steel pipe, 26 ft 5 1/2 in.; 26 ft 9 1/4 in.; and 25 ft 1/4 in. long.)

Test No.	5	6a	6b	7	8	9	12	13	14	15	16	17
Approx. water level, in.	6	7	7	7	7	7	10	10	6	7	7	10
Heating surface, sq. ft.:												
Below water line	1.83	2.63	2.63	2.63	2.63	2.63	5.00	5.00	1.83	2.63	2.63	5.00
Above water line	17.66	16.86	16.86	16.86	16.86	16.86	14.49	14.49	17.66	16.86	16.86	14.49
Total	19.49	19.49	19.49	19.49	19.49	19.49	19.49	19.49	19.49	19.49	19.49	19.49
Steam pressure, lb per sq in. abs.	40	40	40	40	40	40	40	40	40	40	40	40
Temperatures, F:												
Mercury vapor before throttle	1032	1017	1032	1008	1034	1040	1025	1027	1036	1039	1028	1032
Mercury vapor after throttle	808	853	835	750	763	960	725	749	752	809	793	744
Mercury liquid out	384	451	448	459	457	355	289	280	375	398	393	295
Water in	78	82	85	89	79	91	98	83	85	84	89	85
Steam out	637	646	641	555	571	748	513	480	500	491	475	432
Water in drum	267	267	267	267	267	267	267	267	267	267	267	267
Water evaporated, lb per hr	156	190	346	250	321	264	290	420	346	556	531	425
Mean temperature difference, F	142	196	187	193	191	141	86	86	170	211	208	118
Thousands of Btu per hr per sq ft	10.4	12.7	23.0	16.1	20.9	18.2	18.2	26.3	21.8	35.0	33.1	26.1
Btu per hr per sq ft per deg F	73.3	64.8	123.0	83.4	109.5	129.0	211.7	305.9	128.2	166.2	159.1	221.1

(1) Superheated mercury vapor being cooled by superheated steam.

(2) Mercury vapor at decreasing pressure and temperature being condensed by superheated steam.

(3) Mercury vapor at rapidly decreasing pressure and temperature being condensed by boiling water.

(4) (Doubtful) Liquid mercury being cooled by boiling water.

The coefficients of heat transfer in these four zones differ very widely. The relative length of these zones is dependent on the heat to be transferred in each zone, the mean temperature difference in each zone, and the coefficient of heat transfer obtained in each zone. Because of the many unknowns involved, it is obviously impossible to obtain coefficients of heat transfer for the individual zones. It is also impossible to arrive at an overall heat-transfer coefficient which will represent any one type of heat transfer.

The mean temperature over all the surface on either side is indeterminate; therefore, the mean temperature difference is indeterminate, and however accurately the heat per hour per square foot may have been determined, any value of a degree coefficient would be largely academic and of no real value.

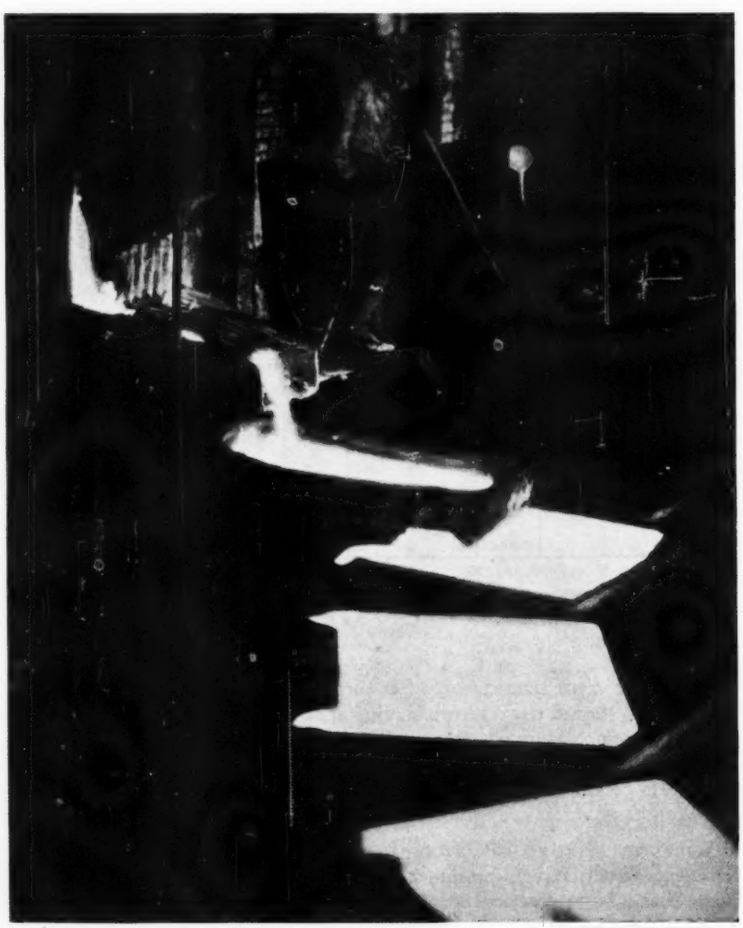
The coefficients of heat transfer which are plotted in Fig. 3 were obtained by dividing the average Btu per hr per sq ft by a logarithmic mean temperature difference between the measured temperature readings, i.e., referring to Fig. 2,

$$T_m = \frac{(T_1 - t_1) - (T_2 - t_2)}{\log_e \dfrac{T_1 - t_1}{T_2 - t_2}}$$

It must be definitely pointed out that this procedure is not justifiable and that the mean temperature difference values thus obtained have no meaning or value. However, the coefficients of heat transfer arrived at in this manner undoubtedly represent very conservative values in comparison to what could actually be obtained.

There is no question that the greater part of the heat transfer took place below the water level. In the tests of Table 1, the heating surface below the water level varies from 10 to 30 per cent of the total. Therefore, it may be said that the transfer coefficients obtainable in a mercury condenser are of the order of magnitude of from three to ten times the values given on Fig. 3. It is, therefore, reasonable to expect an overall coefficient of heat transfer from condensing mercury to boiling water of at least 200 to 400.

The data are presented in Fig. 4 in the form of a plot of heat transfer in Btu per hr per sq ft versus mean temperature difference.



Nesmith, N. Y.

DROP *Versus* FILM FORMATION *in the Condensation of Steam on* CONDENSER TUBES

By J. O. JEFFREY AND J. R. MOYNIHAN[1]

DURING some experiments undertaken to determine the effect of the size of the thermocouple wires upon the indications of the couples, it was noted that the indications varied over a range of approximately ± 2 C in a very irregular and erratic manner. The apparatus in use is shown diagrammatically in Fig. 1. It consisted at the outset of a $^3/_4$-in.-pipe-size copper condenser tube about 2 ft long, held by glands in two heads enclosing the ends of a piece of 6-in. pipe. Four copper-constantan couples with wires of various diameters were soldered into the tube surface in the usual manner, while a fifth couple in the steam space was used to measure steam temperature. The temperature rise of the circulating water was also measured by thermocouples of the same type.

In order to discover the reason for the erratic behavior of the indications of the tube couples, the 6-in. pipe was replaced by a cylinder of Pyrex glass. It was then noted that the condensation took place in drop or drip form as indicated in Fig. 2, which at once explains the cause of the disturbance. Instead of the formation of a continuous film, which is usually assumed to occur, the process of condensation begins with the formation of a large number of very fine droplets on any given area. These droplets then coalesce, and when the larger drop has attained a size so that gravity overcomes the adhesive force between drop and metal surface, the drop slides off to the side. Some drops reach the bottom of the tube before falling off, others, however, break away at various points around the 180-deg arcs on either side. In the wake of the sliding drop, the trace left is apparently perfectly bare for an instant. But almost immediately the small drops again begin to form, and the action is repeated. At any one time a considerable percentage of the total area of the tube surface appears bare. The entire action here described was recorded on a moving film, so that it could be studied at leisure.

When a drop of some magnitude gathers over one of the couple junctions, it acts as a resistance and the heat is abstracted from the junction by the copper wall with great rapidity. This accounts, of course, for the erratic indications, and incidentally raises a serious question as to the reliability of any previous measurement of average surface temperature in the case of condensing vapors.

The phenomenon described is not new. The first extensive mention of it occurs in an article by Schmidt, Schurig, and Sellschopp on "Versuche über die Kondensation von Wasserdampf in Film—und Tropfenform," in *Technische Mechanik and Thermodynamik*, vol. 1, no. 2, February, 1930. This same work was reviewed by Wulfinghoff in MECHANICAL ENGINEERING, July, 1933, and it is also mentioned by McAdams in his recent book on heat transfer.

Both Wulfinghoff and McAdams seem to draw from the experiments cited the conclusion that drop condensation occurs only on a very smooth tube surface and that it is an unstable phenomenon. The authors have found, on the contrary, that the ordinarily commercially clean copper surface normally gives drop condensation, while it seems to require special conditions or efforts to produce and maintain anything like 100-per cent film formation. In order to study the action in some detail the following series of tests were made.

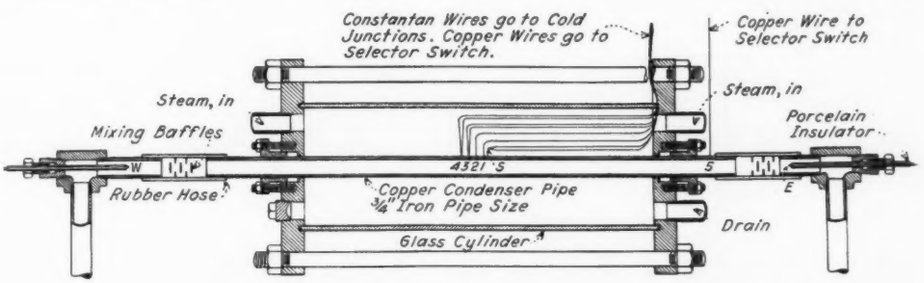


FIG. 1 DIAGRAM OF TEST APPARATUS

TESTS ON COMMERCIALLY CLEAN TUBE

A preliminary study was made on a commercially clean $^3/_4$-in.-pipe-size electrolytic-copper condenser tube. This tube normally showed drop condensation either at high or low water velocities through the tube (range from about 1.75 to 8.50 fps) and at high or low steam velocities. The latter could not be directly measured. As Fig. 1 shows, steam could be admitted through either head, the excess escaping through a vent opening in each head, not shown in the drawing. A small excess of steam, as noted at the escape openings, the steam being admitted through both heads at the same time, as well as a high rate of supply from one side only, produced no change in the type of condensation. With the lower steam supply, the drops ran off vertically; with the higher rate of supply they ran off at angles as great as 30 deg from the vertical, being blown by the steam currents. Drop condensation continued for a total time of operation in excess of 120 hr, even

[1] Instructors in the Department of Experimental Engineering. Work done in the laboratory of the Sibley School of Mechanical Engineering, Cornell University, Ithaca, N. Y., under the general direction of Prof. A. C. Davis.

FIG. 2 DROP CONDENSATION ON COMMERCIALLY CLEAN COPPER TUBE

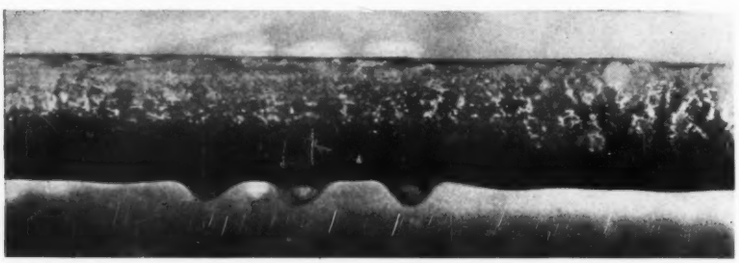


FIG. 3 FILM CONDENSATION ON TEST TUBE AS RECEIVED AND AFTER CLEANING ON INSIDE ONLY

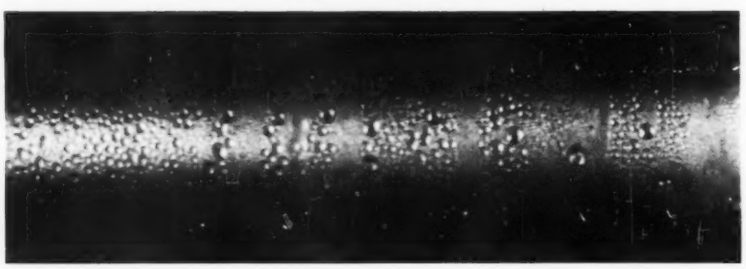


FIG. 4 DROP CONDENSATION ON TEST TUBE COMMERCIALLY CLEAN INSIDE AND OUTSIDE

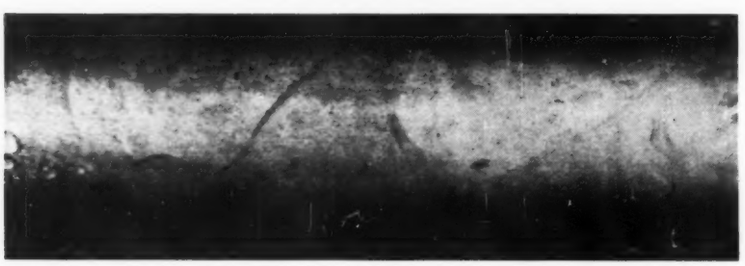


FIG. 5 FILM CONDENSATION ON TEST TUBE AFTER WASHING WITH NITRIC AND CHROMIC ACIDS, CHEMICALLY CLEAN OUTSIDE

after the tube was blackened by oxide formation.

The German experiments indicated that film condensation could be forced by etching the surface of the tube with soldering solution. Attempts to repeat these results were not successful, it being impossible to obtain 100-per cent film formation after various etching periods, either with the copper tube, or with the Muntz metal tube to be mentioned next.

TESTS ON CONDENSER TUBE TAKEN FROM SERVICE

The principal tests were made on a length of No. 18 gage, Muntz metal condenser tube furnished by A. D. Bailey, superintendent of generating stations, Commonwealth Edison Company, Chicago. This tube had been in service for approximately 25 years in a vertical unit at the Fisk Street Station. The outside diameter of this tube was 1 in. This tube, as received, was coated on the outside with a thin dark-gray layer of what appeared to be a mixture of black oxide and dried sludge, while the inside was covered with a thin layer of carbonate scale. It appeared afterward that the surface of the metal itself was slightly pitted. Tests were undertaken to determine the heat-transfer qualities of this tube (*a*) as received, (*b*) as cleaned mechanically inside, (*c*) as cleaned mechanically both inside and outside, (*d*) as etched, and (*e*) as oiled, and to study the type of condensation under each of these conditions.

Generally, the tests were carried out with steam at atmospheric pressure, and with the mean water temperature at about 75 F. It was found that the overall coefficient of transfer seemed to be independent of the rate of steam flow through the device, but that a marked increase in the mean water temperature caused a marked increase in the coefficient. This must be attributed to the decreased resistance to heat flow on the water side, due to lower viscosity of water and thinner stationary water film. The rise of the coefficient with increasing water velocity through the tube is also to be ascribed to the thinner water film and to the effect of increasing turbulence. The heat transferred was computed from the weight of water inflow and the temperature rise. This was not checked against the heat accounted for in the condensate, as no attempt was made to collect the drip from the tube separately. This

TABLE 1 DATA AND RESULTS OF TESTS ON CONDENSER TUBE AS RECEIVED

Test no	13	14	15	16	17	20	21	22	23
Water supply, W, lb per hr	2,820	2,800	2,805	4,100	4,060	8,300	8,230	1,759	1,752
Water velocity, v, fps	2.89	2.86	2.88	4.12	4.08	8.35	8.30	1.77	1.77
Water temp, inlet, T_1, F	152.7	150.7	154.0	73.8	74.2	72.7	72.5	75.1	75.1
Water temp, outlet, T_2, F	155.2	153.2	156.8	77.8	78.2	75.2	74.9	82.4	82.5
Temp diff., $T_2 - T_1$, F	2.50	2.50	2.80	4.00	4.00	2.50	2.40	7.30	7.40
Temp diff. by potentiometer, Δt, F	2.60	2.60	2.60	4.03	4.03	2.45	2.45	7.20	7.25
Total heat transfer, Q, Btu per hr	7,330	7,280	7,280	16,520	16,350	20,300	20,100	12,670	12,700
Heat transfer, Q', Btu per hr per sq ft	19,040	18,900	18,900	43,000	42,500	52,800	52,300	32,900	33,000
Steam temp, T_s, F	210.8	210.8	210.8	210.7	210.7	210.8	210.8	210.9	210.9
Mean water temp, T_m, F	154.0	152.0	155.3	75.8	76.2	74.0	73.7	78.8	78.8
Mean temp diff., $T_s - T_m$, F	56.8	58.8	55.5	134.9	134.5	136.8	137.1	132.1	132.1
Overall coef, U, Btu per hr per sq ft per deg F	335	322	340	319	316	386	381	249	250

study was not so much directed toward the accurate determination of the coefficients of transfer as it was toward the observance of the variation of this coefficient with tube condition and type of condensation. However, the weight of water inflow was very accurately determined. The temperature rise was measured in two ways, once by the difference of the individual couple readings at inlet and outlet, and again by a direct reading of the difference Δt by connecting the couples differentially. The concordance of these two methods is shown in Tables 1, 2, and 3. The differential reading Δt of temperature rise is used in the computations as being the more reliable. The active surface area of the test tube was 0.385 sq ft.

For the reason also that not sufficient tests were run, no attempt is made to derive mathematical expressions for the graphs nor to correlate these results with those of other experiments.

The tube tested in the conditions as received gave 100-per cent film condensation. Its appearance in action is shown in Fig. 3. The condensate separates in large drops along the lowest element of the tube. The results, from Table 1, plotting coefficient against water velocity on log-log paper, are represented in line 1 of Fig. 6. Note the considerably higher values that are obtained with hot water in Tests Nos. 13, 14, and 15.

The tube cleaned on the inside continued to give 100-per cent film condensation and appeared as in Fig. 3. The results from Table 2 are plotted in line 2, Fig. 6. As might have been expected, the decrease in total resistance resulting from the removal of the scale from the inside of the tube, resulted in higher values of U for the same values of v. Here again, higher mean water temperature results in still higher values of U, Test Nos. 10, 11, 12, and 13.

In the tests with the tube cleaned on inside and outside, the condensation took place under drop formation, Fig. 4. The results from Table 3 are plotted in line 3, Fig. 6. The values of U were the highest obtained on these tests, being from two to four times the values obtained with the tube as received, depending upon the velocity. The rate of increase grows with the velocity. The result is primarily attributable to the change from film to drop condensation, and constitutes the best argument for a tube clean inside and out that the authors

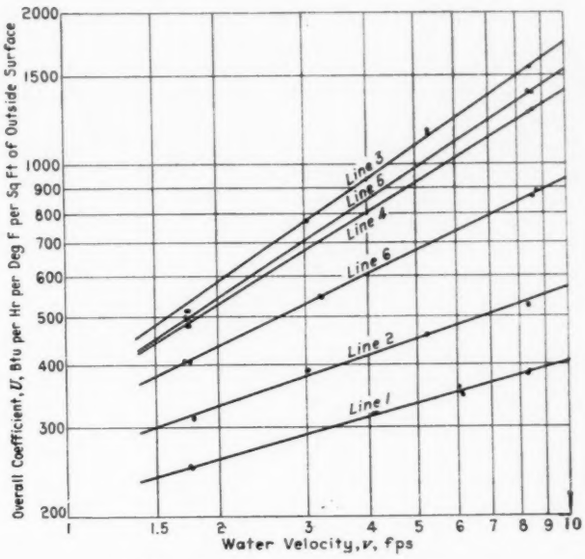


FIG. 6 RESULTS OF CONDENSER-TUBE TESTS

(Tube taken from a condenser in service since 1908. $17^5/_8$-in.-section from most contaminated portion used in tests. Outside diameter of tube, 1 in.; No. 18 gage; material, Muntz metal.)

Line 1 Tube as received, 100-per cent film condensation
Line 2 Tube clean on inside only, 100-per cent film condensation
Line 3 Tube clean on both inside and outside, 100-per cent drop condensation
Line 4 Outside of tube etched 66 hr with zinc chloride, 40-per cent film
Line 5 Outside of tube etched 154 hr with zinc chloride, 25-per cent film
Line 6 Outside of tube washed with nitric and chromic acids, 100-per cent film

TABLE 2 DATA AND RESULTS OF TESTS ON CONDENSER TUBE CLEANED ON INSIDE ONLY

Test no.	1	2	3	4	5	6	7	8	9	10	11	12	13
Water supply, W, lb per hr	8,275	8,310	1,770	1,770	1,770	3,020	3,010	5,180	5,200	1,810	1,820	2,793	2,781
Water velocity, v, fps	8.35	8.36	1.78	1.78	1.78	3.04	3.02	5.21	5.23	1.86	1.86	2.86	2.85
Water temp, inlet, T_1, F	72.5	72.3	74.7	74.5	74.7	73.7	73.7	72.6	72.5	155.8	149.4	150.6	149.2
Water temp, outlet, T_2, F	75.8	75.6	83.6	83.5	83.7	80.5	80.5	77.2	77.1	160.3	154.0	154.0	152.8
Temp diff., $T_2 - T_1$, F	3.30	3.30	8.90	9.00	9.00	6.80	6.80	4.60	4.60	4.50	4.60	3.40	3.60
Temp diff. by potentiometer, Δt, F	3.34	3.30	8.92	8.90	8.86	6.64	6.64	4.63	4.66	4.47	4.67	3.37	3.54
Total heat transfer, Q, Btu per hr	27,600	27,400	15,800	15,750	15,700	20,500	20,000	24,000	24,200	8,100	8,500	9,410	9,840
Heat transfer, Q', Btu per hr per sq ft	71,700	71,250	41,100	41,000	40,800	52,100	51,900	62,400	62,900	21,050	22,080	24,450	25,550
Steam temp, T_s, F	210.85	210.85	210.85	210.85	210.85	211.0	211.0	211.0	211.0	211.07	211.07	211.07	211.07
Mean water temp, T_m, F	74.15	73.95	79.15	79.00	79.20	77.00	77.00	74.90	74.80	158.05	151.70	152.30	151.00
Mean temp diff., $T_s - T_m$, F	136.70	136.90	131.70	131.85	131.65	134.00	134.00	136.10	136.20	53.00	59.40	58.60	60.10
Overall coef, U, Btu per hr per sq ft per deg F	525	521	312	311.5	311	389	388	458	450	397	372	417	425

TABLE 3 DATA AND RESULTS OF TESTS ON TUBE CLEANED ON INSIDE AND OUTSIDE

Test no.	1	2	3	4	5	6	7	8	9	10
Water supply, W, lb per hr	8,460	8,460	1,727	1,733	3,000	3,015	5,270	5,260	2,793	2,817
Water velocity, v, fps	8.51	8.51	1.74	1.75	3.02	3.04	5.31	5.30	2.88	2.90
Water temp, inlet, T_1, F	71.2	70.8	73.8	73.8	72.6	72.7	70.7	70.4	160.2	160.0
Water temp, outlet, T_2, F	80.8	80.5	88.6	88.6	86.0	86.0	82.0	82.1	166.5	166.0
Temp diff., $T_2 - T_1$, F	9.60	9.70	14.80	14.80	13.40	13.30	11.30	11.70	6.30	6.0
Temp diff. by potentiometer, Δt, F	9.53	9.55	14.82	14.79	13.12	13.00	11.22	11.50	6.20	6.06
Total heat transfer, Q, Btu per hr	80,600	80,700	25,600	25,630	39,360	39,200	59,200	60,500	17,300	16,900
Heat transfer, Q', Btu per hr per sq ft	209,000	209,500	66,500	66,600	102,200	101,900	153,900	157,100	45,000	44,000
Steam temp, T_s, F	210.9	210.9	210.8	210.8	210.8	210.8	210.8	210.8	210.4	210.4
Mean water temp, T_m, F	76.0	75.7	81.2	81.2	79.3	79.3	76.3	76.1	163.3	163.0
Mean temp diff., $T_s - T_m$, F	134.9	135.2	129.6	129.6	131.5	131.5	134.5	134.7	47.1	47.4
Overall coef, U, Btu per hr per sq ft per deg F	1,552	1,552	514	514	778	775	1,146	1,167	955	930

have seen. Tests Nos. 9 and 10 again show higher than average increases with hot water in circulation.

TESTS WITH ETCHED TUBE

Following the German experiments, the tube was next etched with soldering solution in an attempt to force film condensation on the commercially clean tube. The method proved unsuccessful. Etching for a short time only produced no change in the type of condensation. Etching for 66 hr produced a condition which was estimated at 40-per cent film and 60-per cent drop condensation. The results obtained under this condition are indicated in line 4, Fig. 6. It was assumed that the effect of etching was to produce a large number of very small pits, which, after filling with condensate, would tend to overflow and coalesce with their neighbors, thus forcing a complete film. The etching was therefore continued for a total of 154 hr, but the only result was to decrease the film surface to about 25 per cent. The theory is therefore wrong. The results obtained under this condition are indicated in line 5, Fig. 6. As might be expected, lines 4 and 5 lie lower than line 3 in proper order.

It was next assumed that the drop formation might be due to an infinitesimally thin film (greasy film) with which all surfaces are naturally covered unless special efforts are made to remove it. This film may be assumed to change the surface-tension relations in such a way as to make it impossible for the water to wet the surface and to form a continuous film. In accordance with this theory, the tube was polished with emery and crocus cloth, in order to remove any traces of the previous etching with soldering fluid, and it was then quickly washed, first with nitric, rinsed in water, next washed with chromic acid and immediately rinsed again. The tube so treated may be considered "chemically" clean and gave 100-per cent film condensation with the results indicated in line 6, Fig. 6. Fig. 5 shows the condition while in action. While the film was maintained indefinitely under this treatment, it is very unstable. After the runs were completed and during the preparations for the taking of the picture, a cleaning rod with apparently clean cheese-cloth at its end was introduced through the vent opening in one head in order to remove drops of condensate adhering to the inside of the Pyrex cylinder. The cheese-cloth accidentally touched a portion of the tube and the type of condensation in the touched area immediately changed from film to drop, as may be noted at the extreme left end of the tube in Fig. 5. Apparently the cloth carried traces of oil.

For lines 3 and 6 of Fig. 6, the tube appears superficially to have exactly the same degree of cleanliness. The difference is that in the latter case the greasy film has been artificially removed, producing a condition which changes at once when the tube is handled in any way, and the removal of this invisible film changes the type of condensation completely.

TESTS WITH OILED TUBE

The German experiments also indicated that if the commercially clean tube surface were wetted with kerosene, temporarily higher coefficients could be obtained than with the commercially clean tube working with drop condensation. Tests made to check this conclusion do not give the indicated result. Wetting the tube either with kerosene or 600 W cylinder oil gives very much lower values of U whether the tube is covered with a thick or thin film of the lubricant. Condensation takes place by drop formation and it is assumed that the lower values of U result from the added resistance of the oil film. As the test progresses, the value of U at any given velocity steadily rises, due to the gradual washing off of the oil film, until the values practically coincide with those shown by line 3, Fig. 6, for the same water velocities. At no time were higher values obtained even temporarily.

CONCLUSIONS

(1) Condensation of steam on condenser tubes takes place in drop formation as long as the tube is "commercially" clean. This action is probably due to the effect of a very thin film of lubricant (so-called greasy film) with which all surfaces exposed to the air for any length of time are apparently covered. The effect of this film appears to be to cause water to fail to wet the surface completely. Hence the drop formation.

Contrary to the opinion of some other observers, drop condensation does not require either very highly polished (chrome-plated) surfaces or low steam velocities, for in the experiments under discussion here, it was not possible to get anything else than drop condensation on a commercially clean tube at any steam or water velocity within the range of the apparatus. Even a thin oxide film, turning the tube black after some 120 hr did not change this condition.

Whether higher or lower steam pressures, or more or less air in the steam, would have affected this general result was not determined in these tests.

(2) If the greasy film is removed by special means, making the surface "chemically" clean, the type of condensation changes to the film form, with a consequent decrease in the value of the transfer coefficients. But this is an unstable condition, the slightest contamination of the surface causing a reversion to drop condensation.

(3) There is evidence to show that in actual use, as the commercially clean tube becomes covered on the outside with an oxide layer, and particularly with a layer deposited by the impurities in the steam, the type of condensation gradually changes from drop to film form. How long a time is required for this change is, of course, a function of the conditions in a given plant. Since there is a remarkable difference between the transfer coefficients in the two types of condensation, special efforts to maintain tubes "commercially" clean outside as well as inside would be a good investment. As a matter of fact, it appears more important to keep the tube clean on the steam side than on the water side, although probably much more difficult.

WHAT IS PROPER METHOD OF MEASURING SURFACE TEMPERATURES IN HEAT-TRANSFER EXPERIMENTS?

Finally, from the standpoint of measurement, these tests raise very definitely the question of the proper method of measuring surface temperatures in experiments made to determine film coefficients of heat transfer with any condensing vapor. In work on overall coefficients this question is, of course, not involved. It does not seem to the authors adequate in the measurement of surface temperatures simply to connect two or more thermocouples in the usual fashion, and then to regard the mean of the readings so obtained as the mean surface temperature of the entire surfaces. As long as drop condensation persists in any test, this method may be subject to very considerable errors. As a matter of fact, an entirely satisfactory method of measuring mean surface temperatures of extended tube surfaces does not, as yet, seem to be in existence. The study here reported on is part of a series of experiments to determine film coefficients in the condensation of steam with various amounts of air. The progress of the work is very definitely held up by the failure so far to find a really acceptable method of measuring surface temperatures. Any hints toward the solution of this problem will be gratefully received.

SIMPLICITY *the* KEY *to* ACCURACY

Getting Back to Fundamentals to Insure Accuracy in Quantity-Production Manufacture

By G. M. EVANS[1]

THE ACCURACY necessary in the manufacture of our product could not be obtained by using the commonly accepted methods and practises of quantity interchangeable production. In dealing with tenths[2] and fractions of tenths, ordinary methods of machining, locating, clamping, etc., developed difficulties due to temperature changes, clamping warpage, and other irregularities that forced us to go back to the fundamentals of mechanics. From that point on our whole program of manufacture was built around the V-block, arbor, and surface plate. This was true of inspection as well as production; and any deviation from these fundamentals brought in errors not only in the work itself, but in the indication of the accuracy of that work.

For interchangeability of parts within the necessary limits, it was vital that the method of locating should be such that an unskilled operator could repeat easily, accurately, and quickly the position that was held when going through the machining process.

FINISHING A WRISTPIN HOLE

For example, the wristpin hole in the compressor piston must be absolutely square with the piston axis, round, and straight, so that the difference of two-tenths between the "go" and "no-go" gage can be maintained after taking the work off the machine, re-setting quickly, and sending over the same tools that first made the finished hole. This can be done any number of times without changing the "feel" of the "go" gage and having the "no-go" refused. The difference of a tenth in the diameter of the hole gives a difference in the "feel" that the most unskilled operator can easily recognize. While the tolerance between the "go" and "no-go" gage in actual practise is two-tenths, it is a common occurrence to be able to have a "go" feel the same before and after sending the finishing tool through on a re-location. A difference in the size of the hole such as this is unmeasurable. The two-tenths tolerance is to take care of the wear of the tool, giving a longer life per grind, and still obtaining the fits necessary for selective assembly.

This work is done on the bed of a standard lathe as shown in Fig. 1. Piston 2 is placed on the V-block 1 against a stop to give the proper head clearance and held in position by a spring tension against a close fitting semi-circular clamp 3. With the wristpin hole previously rough bored, the piston is located laterally in the V-block by a loose arbor which is lined up true with the travel of the ways by aligning fingers 4. A semi-finished cut is taken with the boring bar 5 and the carriage traversed for a finished cut with boring bar 6.

V-block 1 is lined up as follows: A straight arbor is clamped to the carriage and is passed by two fixed indicators, one indicating the top and the other the side of the arbor. When these indicators show no reading on the full travel of the carriage, the axis of the arbor is parallel with the travel of the carriage. An arbor is placed in V-block 1 with a steel ball on the bottom and is trammed until the indicator shows zero. The V-block is then square with the axis of the arbor and therefore square with the travel of the carriage.

We were astonished to note that with a loose arbor in the finished wristpin hole, aligning fingers 4 would so re-locate the hole that when the same piston was traversed a second or third time against the finishing tool, there was no difference of "feel" of the "go" gage.

The same squareness is tested in inspection with a standard V-block and the surface plate as shown in Fig. 2, locating from the side of the cylinder that was used in the work process with the multiplying effect of an arbor in the wristpin hole. It is nothing unusual to find no indication on the 7-in. arbor under a "tenth" indicator. With the holes so square and true, a metal-to-metal fit can be used in the wristpins (held to one-quarter of a tenth on all dimensions) without scoring, thereby overcoming the "noise" that was once one of the most troublesome items.

The advantages of using the V-block as an inspection fixture are: (1) it is fundamentally correct, (2) it is quick to check, and (3) it is easily replaced "from the shelf."

The piston referred to is of cast iron and the hole 0.500 in. in diameter. The roughing operation is done at 3400 rpm with a cutting speed of 445 fpm and a feed per revolution of 0.0007 in. The finish operation is done at 3200 rpm, 420 fpm cutting speed, with a feed of 0.0007 in. per revolution.

THE CONNECTING ROD

To obtain in the connecting rod two true, straight, round, parallel holes without wind, the V-block could not be applied. An angle plate was employed, using a surface plate for the carriage of the lathe. The angle plate was lined up true with the travel of the carriage within one tenth by means of a 36-in. straight edge. Clamping the connecting rod to this fixture and traversing it past two rotating tools, necessarily gave two holes that were parallel with no wind. Any wind or lack of parallelism in the finished piece indicated warpage and immediately gave evidence of trouble in clamping. When this was corrected, two true holes were obtained.

The fixture for doing this work is shown in Fig. 3. Clamp 1 has a ball point directly over a knife edge locating the flat side of the connecting rod. This clamp must have a close fit with its guides, as a slight movement here will give wind. Clamp 2 has a ball directly over a single point on the angle plate, thereby giving a three-point location. This clamp also must fit closely in its guide or wind will result. The two boring bars 3 and 4 are lined up approximately parallel with the travel of the carriage, the axes of which are the proper distance between the two holes. The squareness of the spindle

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[2] Throughout this paper, "tenth" means 0.0001 in.

Presented at a meeting of the Detroit Section, Detroit, Mich., October 4, 1933, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Slightly abridged.

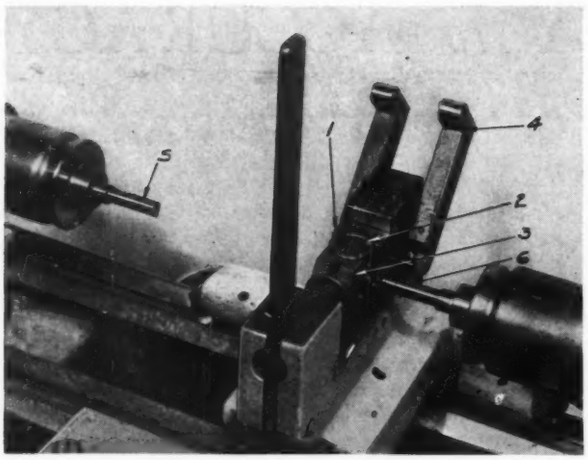

FIG. 1

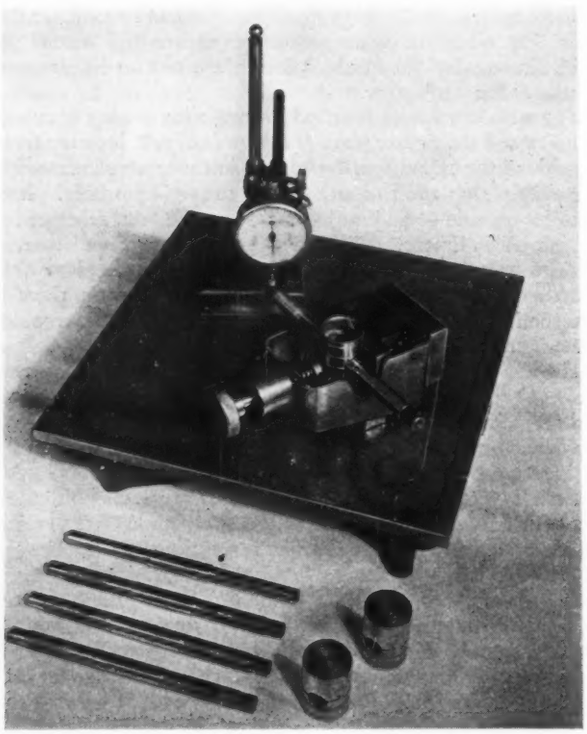

FIG. 2

with the travel of the carriage is not important within reasonable limits.

The tests of the connecting rod are shown in Fig. 4. Parallelism is being tested at 1, and wind at 2.

BORING TWO TRUE PARALLEL HOLES

In boring two true parallel holes within a parallelism of one-tenth in 12 in., it was necessary to go back to mechanical fundamentals, locating an arbor from V-blocks on a surface plate. After the crank hole of the compressor cylinder block is bored true in the same manner as the wristpin hole, an arbor is wrung into it and used for locating two V-blocks on a surface plate by the carriage.

When a hole is bored from this set-up any lateral movement of the arbor in the V-blocks to a new location will give a hole parallel to the first one. The illustration of the machine used for this work, and its fixture is shown in Fig. 5.

Arbor 2 is wrung into the crank holes of the twin-cylinder block 1 and located in the V-blocks 3 and 4, being held in place by springs in fixtures 5 and 6. The V-blocks are previously lined up square with the travel of the carriage. The cylinder block is held against a stop 7 at one end of a lever, the other end of which is the stop for the second hole, the difference between the two radii being the difference between centers of the bores. The cylinder is held against the stop by a wedged clamp 8 whose clamping angle is such that there is no pressure exerted against the side of the cylinder. The lower part of the cylinder head 11 is milled approximately parallel (any variation here gives only a radial displacement of the cylinders) with the axis of the arbor 2 and is located on a button on plate 9 immediately below the axis of the boring bar 12. Clamp 10 gives a spring tension on a line with the center of the bore of the cylinder against this stop. This puts the lower part of the metal of the cylinder head under compression and does not distort the hole. If the clamp were above, the boring bar would bore a true hole while it was in the fixture but immediately upon release of the clamp the hole would assume an elliptical shape. A further advantage of this method of clamping is that the operator has an unobstructed view of the work while loading and during the operation of boring. The entire fixture being open to view, it is easily kept clean. The principal points of location, the V-block, and the stop 10 are almost self-cleaning.

The size of the hole is 1.250 in.; the boring bar turns at 1700 rpm; the cutting speed is 556 fpm; the feed is 0.0015 in. per revolution; and the material is close-grained cast iron.

MAJOR ELEMENTS IN SET-UP

The major points to be considered in the set-up just described are as follows:

(1) The lathe bed should preferably be a second-hand one that has completed its cycle of distortion and the ways of which have been scraped true.

(2) The best spindle obtainable should be used so that it will be in dynamic balance at its cutting speed. A thin, flexible, endless canvas belt will prevent momentary changes in speed.

(3) One "V" on the lathe should be used, this "V" being parallel to a flat on the other side of the bed. It is only essential to obtain the movement of the carriage in a straight line, no matter where the line may be.

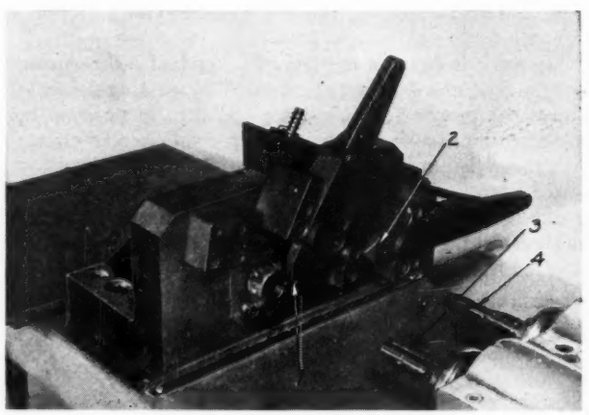

FIG. 3

(4) The material should be uniform in order that the cutting action of the tool may not vary.

(5) A sharp tool should be used to make the cutting action as free as possible.

(6) All parts affecting the movement of the carriage and the accuracy of location should be protected from chips and dirt. The use of the V-block, besides giving the utmost accuracy, also lends itself to easy cleaning.

(7) A separate motor should be used for driving the feeding mechanism. In order to avoid vibration, this motor is not placed on the lathe bed.

(8) Clamping should be arranged so that there is no distortion of the hole after the clamps are released.

(9) The weight of the carriage should be sufficient to avoid vibration.

(10) The feed of the carriage should be as near the center of the work as possible.

(11) The temperature of the lubricant in the spindle and on the ways should be maintained constant while the machine is in operation.

(12) Clamping should be against the locating point in such a way the action of the clamp does not distort the cylinder bore.

The final work on the machine should be done after it is lagged into its final place, thereby correcting any errors that may result from distortion in moving.

SETTING THE V-BLOCKS SQUARE WITH THE LATHE BED

In order to eliminate noise and bind it is essential that the crankcase hole be square with the two bores of the cylinder block. This is obtained in the set-up shown in Fig. 6. The cylinder bores being generated parallel to the movement of the carriage, it is only necessary to line up the V-blocks square with this travel. A 36-in. straight-edge is clamped to the surface of the carriage and traversed past a stationary one-tenth indicator until a zero reading is obtained for its entire length. It is then clamped in place. The two V-blocks 2 and 3 are so lined up with the arbor 4 that when the indicator 5 is trammed over its entire length the reading is zero on a one-tenth indicator. Plate 6 is clamped at the end of V-block 2 with a ball at the end of the arbor 4 for tramming purposes. The V-blocks are then clamped in place with the assurance that the axis is square with the travel of the carriage (or the axis of the bores) within one tenth in 36 in.

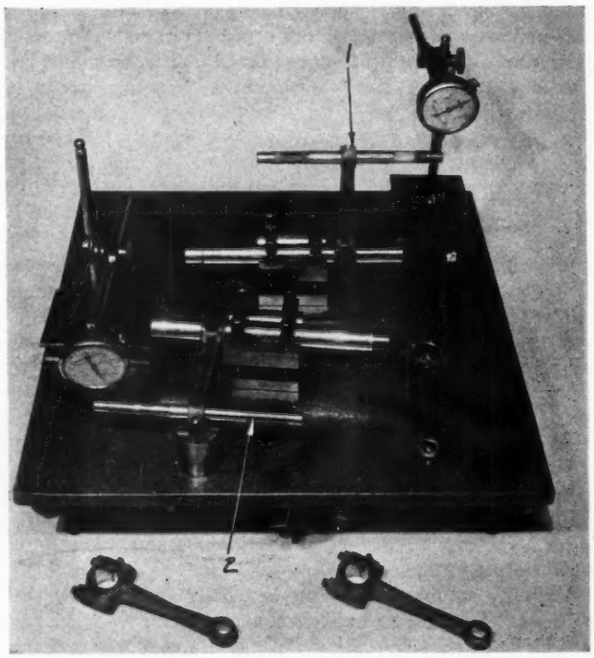

FIG. 4

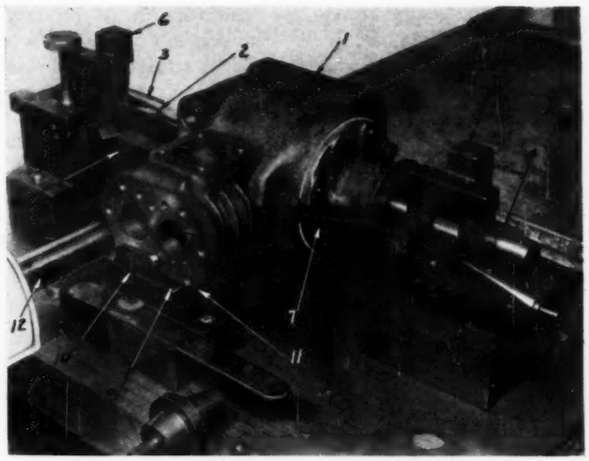

FIG. 5

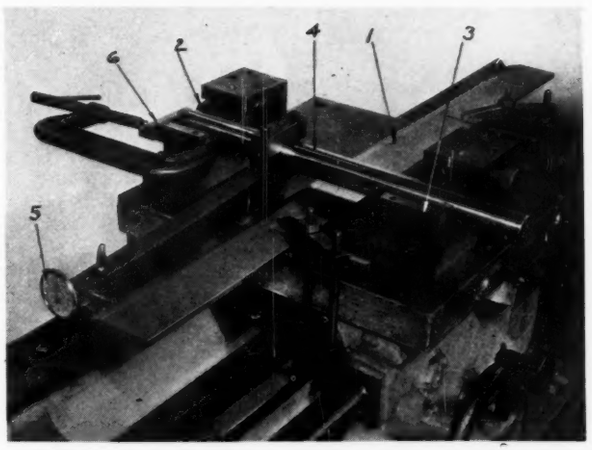

FIG. 6

ACCURACY IN MACHINING AN IRREGULARLY SHAPED PIECE

Difficulty was encountered with the pieces lying on the surface plate in Fig. 8. It was necessary to make the outer diameter of this piece a true circular cylinder, square with the back face, and square with the vane, with taper and eccentricity accurate to within one tenth. Various standard methods and machines were tried out, but here again it was found necessary to revert from the more complex layout to as simple a set-up as could be made.

The machine for doing this work is shown in Fig. 7. The spindle assembly 1 was originally a complicated mechanism with cams, gears, and various safety devices for stopping the machine before the tool cut the vane. These were all stripped from the machine. There is now a straight spindle with one large gear for radial feed. The spindle and its bearing were the best that could be made with a very close fit. In spite of this there is an overrun on the ratchet feed which was corrected by a drag on the gear as shown in 2. The cutting tool is operated

by a standard slotting attachment head from one of the standard makes of milling machines. The bearings of the ram were scraped and fitted so as to obtain a true straight-line motion during its entire stroke. The travel of the ram was lined up parallel with the axis of rotation of spindle 1. This was obtained by first indicating a straight-edge to give a line parallel to the motion of the ram. This straight-edge was used with a master square for tramming in spindle 1 with a 12-in. tram. The entire mechanism is mounted on a bolster plate 4 on the back of which are the various mechanisms for indexing when the ram is

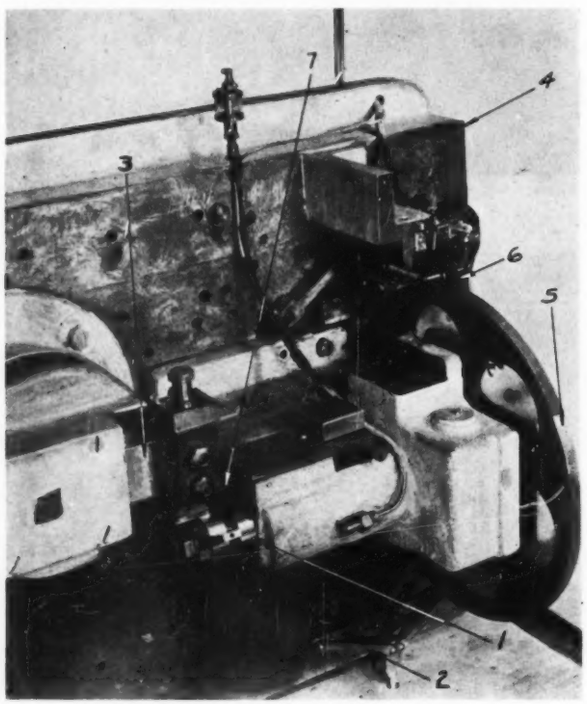

FIG. 7

backed off the work. Recess 5 in the index gear allows the ratchet 6 to drop, thereby breaking the circuit of the driving motor. In case this fails to operate, a lever 7 extending over the travel of the vane will break the main circuit of the motor before the tool in the ram strikes the vane. Both circuit breakers are in series with the main motor.

With this layout it is possible to generate a section of a true circle on each side of the vane square with the back face to within one tenth. The eccentricity, or course, is a function of the fit of the inner hole to the arbor.

The vane is generated on a shaper by two tools, carried in a single tool block, cutting at the same time and feeding away from the circle. With a proper grinding of the cutting tools, it is possible to hold the parallelism of the face of the vane to the back face to within one tenth. With this accuracy, a remarkably fine finish is also obtained.

The inspection layout for the piece whose machining has just been described is shown in Fig. 8. On all operations of the machining processes the back face of the piece is used for location, and therefore on inspection this face is clamped against the master angle plate 2, through which a hole larger than the arbor 3 is bored to allow free movement of the arbor. All indications, then, are referred to the original locating point, that is, the back face. There is no accumulation of errors and any discrepancy immediately shows what operation is at fault. The trueness of the outer diameter for roundness is obtained by rolling on a flat surface under a Zeiss gage. The taper of the outside cylinder and the variations from the plain surface of the vane are obtained by using a gage indicating tenths.

USE OF THE ANGLE PLATE

Having made the upper part of the carriage of the lathe a surface plate with V-blocks mounted thereon, the axes of which are square with the travel of the carriage, it is an easy matter to remove a job and replace it with another by using a set-up similar to the one shown in Fig. 9. Two standard master angle plates, 1 and 2, are assembled on arbors 3 and 4 with a dowel at one end (not shown). At the other end of the angle plate is an adjustable stop (not shown) against which the arbor is held by clamp 5. The flat of the arbor is held against the under side of the angle plate by set screws, using a thin paper gasket immediately around the screw. This was found necessary in order to avoid distortion even though the flat on the arbor was lapped. By laying the angle plate on parallels on its face on a surface plate and indicating across the ends of the arbor, the axis of the arbor is made parallel with the face of the plate. On the rear of the angle plate is a stop (not shown) by which the front surface of the angle plate is made square with the travel of the carriage. Any job with a true face clamped against this angle plate by clamps 6 and 7 and placed interchangeably on any lathe with V-blocks can be bored with a hole square with that face. Parallel holes can be bored at any predetermined distance apart by using the locating point 8. It takes but a few minutes to change the set-up from one job to another, each requiring accuracy within a tenth. An illustration of a typical set-up is shown in Fig. 10 in which the lapped face of the cylinder 1 is placed against the face of the angle plate after being roughly located by a plug. The hole bored is then true with the face. The indication for accuracy of this hole is shown in Figs. 11 and 12 in which the master angle plate is used with the indicators as shown.

Another application of this principle is shown in Fig. 13 in which it was necessary to bore two holes in the cylinder 1 that were parallel within a tenth in 7 in. and squared with the lapped face, keeping the proper distance between centers. The set-up is the same as previously described in which 2 is the angle plate, 3 is the arbor, 4 and 5 the V-blocks, 6 the lever stop for assuring the correct distance between centers, 7 the stop to make the front face of the angle plate square with the travel of the carriage, 8 the spindle, 9 the boring tool for the small hole, and 10 a step-up on the same boring bar for the larger hole. The test for the squareness of these holes is shown in Fig. 12.

ELIMINATING VIBRATION

Vibration troubles were finally overcome by mounting all motors separately from the machine. It was found that vibration as well as chatter was a function of the length of the boring bar. By experiment the length beyond which it was impossible to obtain the results desired, was determined. In the boring bar shown in Fig. 13 the heavy construction necessitated by the second cut of the larger bore permitted a length of $5\frac{1}{8}$ in. In Fig. 5, with the bore of 1.250 in. diameter and a length of $3\frac{1}{4}$ in., the maximum length of the cutting tool from the nose of the spindle was 4500 in. In Fig. 3 the limiting factor is the smaller boring bar 4 whose maximum length was found to be 2.875 in.

Assembly troubles are over when parts are made by these methods. An increase in the amount of scrap was the price paid for lack of noise, for long life, and for lower service charge, but we were agreeably surprised in the last two years to find that the scrap had been reduced by 90 per cent.

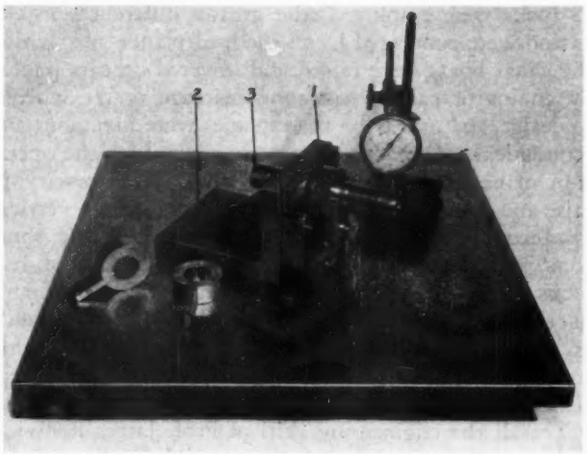

FIG. 8

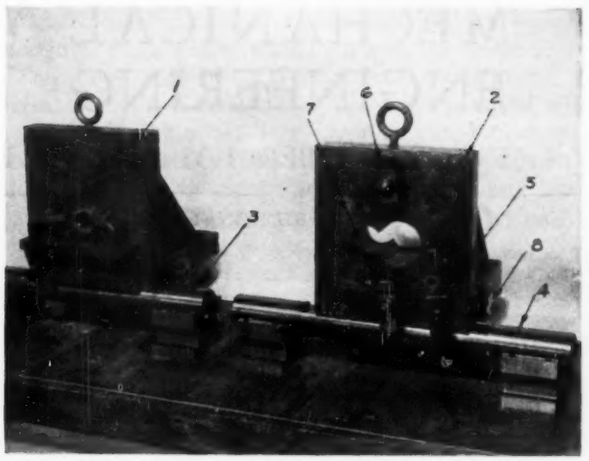

FIG. 9

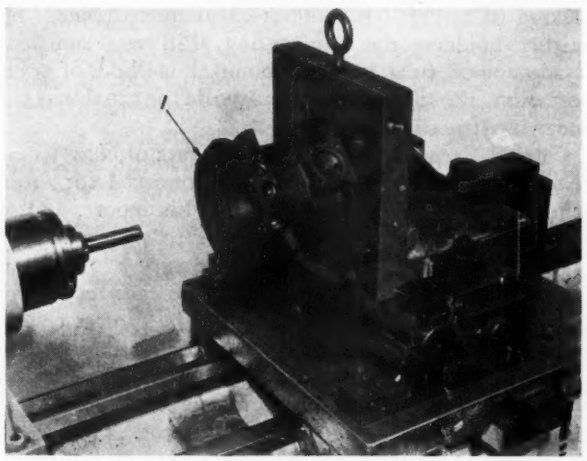

FIG. 10

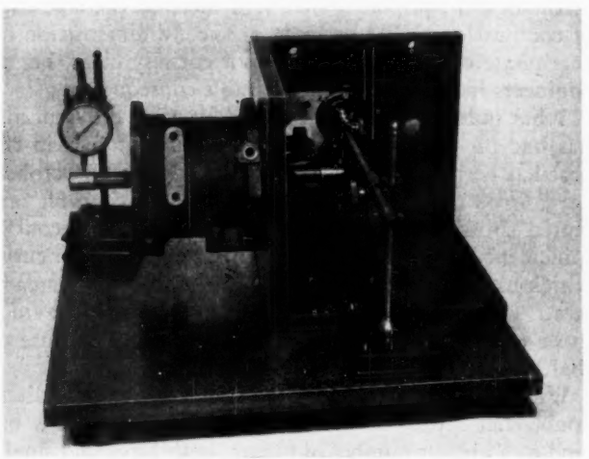

FIG. 11

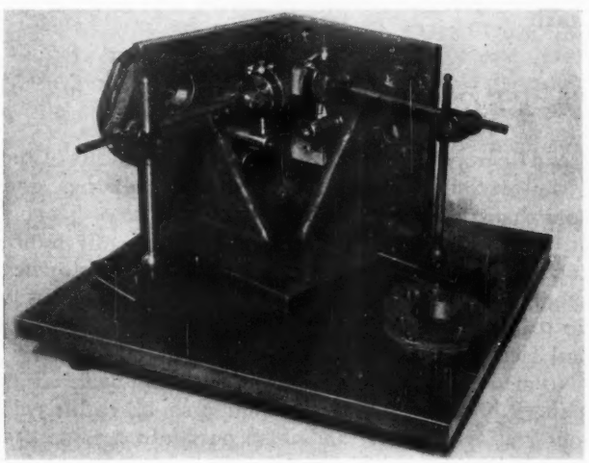

FIG. 12

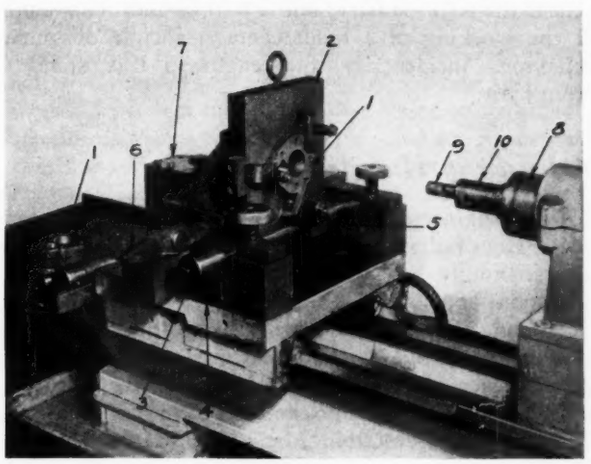

FIG. 13

(For an explanation of these illustrations, see opposite page of paper on "Simplicity the Key to Accuracy," by G. M. Evans)

MECHANICAL ENGINEERING

Vol. 55 DECEMBER, 1933 No. 12

GEORGE A. STETSON, *Editor*

Greater Fuel Efficiency Indicated

INASMUCH as it is one of the acknowledged effects of the NRA to raise prices, there can be no lèse-majesté in reminding engineers that the price of coal will be affected. It is to be expected, therefore, that managers of coal-burning plants will be sympathetic to methods and equipment that will increase the efficiency of combustion. The attitude of the Administration on this phase of reconstruction is not entirely clear, but to engineers it is a logical and desirable consequence.

What influence price, as affected by wage differentials, has had on production and consumption of coal in the past has been analyzed by A. T. Shurick in the October, 1933, issue of *Mining and Metallurgy*. One graph presented shows how the increase in the price of coal is coincident with the leveling-off of the production curve which had, up to that time, mounted upward at a steady rate. During this era there were worth-while savings to be effected by increasing the efficiency of the use of coal.

With mounting costs all along the line, there is little doubt that attempts to increase efficiency will now extend to a greater number of plants, both large and small, and that engineers who are able to show how savings in fuel can be effected will be in demand. This may not benefit the coal industry, but it will be another example of the working of a fundamental principle of human behavior. Incidentally, fuel engineers may stand to profit by it.

A Lesson in Humility

THE engineering features of a project cannot save it from failure if it is economically unsound. This was strikingly brought home to the members of the Newcomen Society in this country who visited Lake Hopatcong, New Jersey, to inspect the few visible vestiges of the old Morris Canal in that district, under the guidance of Cornelius C. Vermuele, Jr., consulting and directing engineer for the dismantling of the canal. For in the paper describing the canal and its engineering features which Colonel Vermuele read, it was pointed out that the canal paid dividends in only one year of its history a century long.

Running for more than 100 miles across northern New Jersey to serve the iron mines of that region, it rose and descended again a total of 2134 feet, and while 28 locks were employed, the greater differences in elevation were connected by 23 inclined planes over which the canal boats were raised and lowered on cars hauled by chains or cables driven by reaction water wheels. In design and operation these planes were ingenious and economical. Only one man was required for the operation of each plane. Moreover, the time necessary to raise and lower the boats, in some cases through vertical distances in excess of 100 feet, was remarkably short compared with what would have been required had locks been used. And while efficiency was not a factor in the operation of the hydraulic turbine inasmuch as water had to be passed in any event from the higher to the lower level, these turbines were of high efficiency.

Yet all the engineering skill of Prof. James Renwick and his colleagues, who were responsible for these excellent designs could not save from financial ruin a project foredoomed to economic disaster. Its promoters were pleased to call it "the boldest canal in existence," but neither boldness nor engineering skill was sufficient. It succumbed to a more economical method of transportation, the railroad, nascent while the canal was still under construction.

Colonel Vermuele, acting for the State of New Jersey, dismantled the Morris Canal, but preserved for future generations a careful record of it in his report, and set up certain monuments and markers to perpetuate the engineering accomplishments of a century ago. As we admire the skill and ingenuity of these early engineers, let us not forget one hard lesson that the project teaches us, that engineering works, however brilliantly conceived and executed, are doomed to failure if they are economically unsound. On this score, if foresight is blind, time will pronounce judgment. One could wish that all projectors of great engineering works might be obliged to stand in humble contemplation before the few remaining monuments of the Morris Canal.

The P.E.C.U. Report

IN HIS report to the Professional Engineers' Committee on Unemployment, Mr. Shoudy has done more than to review the statistical evidence of his committee's worthy acts. He has taken a broadly human view of the problem of unprecedented unemployment among engineers and has written a report that sums up the thinking stimulated by his close contact with the hard facts of a desperate situation.

No man can head up the work of such an undertaking as the P.E.C.U. without a profound shock to his emotions and sympathies, and if he puts into his work as much of himself as Mr. Shoudy has, he expends energies that are slowly if ever recuperated. This, to the regret of every one, Mr. Shoudy has discovered, happily in time. It will be difficult to find a man to fill the place made vacant by Mr. Shoudy's recent resignation, but whoever he may be, he will find the work intelligently planned,

ably administered, and urgently needing the finest efforts that can be expended in its behalf.

As in all periods of stress, the wastage of human values is of greatest concern. Economic conflict brings more widespread suffering than the war of which it is born, for the strategy and tactics of economic warfare are poorly understood. The P.E.C.U. report should start some thinking on the subject of the unemployment problems of engineers that will bring fruitful results extending beyond the period of present stress into the better times that are to come.

The Glove Industry in the United States

WHERE there is a will in industry, a way is practically certain to be found. The development of the glove industry in the United States is a good illustration of this old saying. Before the War, leather for glove making, tanned and colored, was imported from Germany, where the skill of handling it had been developed throughout many generations. It was the general impression in this country that, notwithstanding the existence of a differential tariff between skins and manufactured leather, the glove-leather tanning and coloring industry could not be established here. It was said that this was an industry in which scientific control was practically non-existent, there being sufficient variation in the skins to make scientific control of process difficult. Therefore, practically complete reliance had to be placed on the skill of labor. Men possessing such skill were supposed to be available at a low cost in Germany and Switzerland and completely absent in this country. For this reason, for practically every leather glove made in this country, the wages of a German workman were paid in the purchase price of the imported manufactured leather.

Then came the War, and overnight the supply of glove leather was cut off. Fortunately for the American market, however, the skins themselves did not originate in Germany. Thus it was merely a question of developing in this country methods of tanning and coloring which were quite well known. To the surprise of all those concerned, it was found that, at least under the impetus of the high prices prevailing during the War, men were found who could produce tanned and colored leather of substantially the same quality as that imported from Germany. The result was the creation of an independent American industry of glove-leather manufacture, thus placing the glove-making centers in a safe position in so far as their basic and intermediate materials were concerned.

The present tariff structure offers powerful protection to the American manufacturers. This does not prevent the importation of a certain amount of manufactured skins from Europe, chiefly specialties used in smaller quantities than American manufacturers care to handle. The industry, however, is firmly established, which shows that no matter what the handicap may be, if the raw materials are available and the supply of goods is withheld from the market, somebody will have brains enough to find a way to satisfy the existing demand.

The glove industry in this country, unlike that in Germany and Switzerland, is becoming more and more mechanized, and some very ingenious machinery, particularly for cutting and sewing, has been extensively adopted. There is more and more talk among glove makers that sooner or later still more machinery will be employed in an effort to keep the prices of the product down as much as possible in the face of the rising costs of labor and raw materials.

Interest in Durable-Goods Industries

BELATED cognizance is being taken of the variously termed producer-goods, capital-goods, durable-goods, or heavy industries. While it looked at one time as though the Administration had forgotten this major factor in sound and permanent recovery, it is gratifying to note that attention is at last being turned in this direction.

As Mr. McNiece pointed out last month, the swings away from normal of these industries are much more violent than the corresponding swings suffered by consumer-goods industries. Colonel Ayers, using slightly different categories of products, shows this same characteristic, and points out that while in 1929 the numbers of persons employed in the groups of industries covered by his figures were 4.5 millions and 3.6 millions for the durable- and consumption-goods industries, respectively, the reduction in employment by August, 1933, amounted to 1.9 millions in the first case, and only 360,000 in the second. He adds, "The significance of this lies in the fact that almost the whole effort of the NRA to increase consumer purchasing power is one that promises to help consumer-goods industries where there is little unemployment and offers little for the durable-goods industries where there is great unemployment."

It is safe to say that there are more engineers gaining their livelihood in the durable-goods industries and in services dependent upon them than there are engaged in the consumption-goods industries; and hence the great unemployment among engineers is the result of their being so connected. The engineer's interest in the recovery and stability of these industries is thus identical with the interest of the greater group of unemployed workers.

As reported elsewhere in this issue, a committee is being formed within the A.S.M.E. to concern itself with the stimulation of the recovery of the durable-goods industries. The problem is most practical and the committee's contribution to its solution will be an extremely valuable one. Nor should interest in the problem be confined to the recovery period. It should become a major function of engineering societies to keep in touch with the economic history of these industries, to be alive to the significance of such variations as will occur in them, and to assist in intelligent and practical attempts to stabilize them.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

AIR MACHINERY

An Investigation of the Principles of the Air Injector

THIS report deals with experiments on the working of the air injector with a view to applying its principle to the improvement of the high-speed induced wind tunnel.

Pitot- and static-tube exploration of the jet and its immediate neighborhood showed the presence of standing waves in the jet near the nozzle, and the use of the static pressure along the axis as the distance from the nozzle increased. The photographic method of flow exploration confirmed the results of the pitot-tube exploration and showed: (*a*) that the approach of the surrounding air to the induced cone is approximately at right angles to its surface, and in paths concave toward the nozzle; (*b*) that there is comparatively little actual mixing of the induced with the high-pressure air for some distance from the nozzle; and (*c*) the total angle of the cone of induced air is about 22 deg, not altering greatly with the nozzle pressure.

The influence of a large number of factors has been investigated and it was found among other things that the mass-ratio of a given extractor was rather lower than that of the same jet working as an injector against the same pipe resistance.

An investigation of the effect of the expansion ratio of the diffuser showed that the maximum useful value increased with the flow, but that over the range of the tests (up to a speed of 200 fps), a value of 4:1 appeared sufficient in all cases. It was also found that the efficiency, when plotted against delivery pressure, showed a maximum value at about $^1/_3$ of the maximum delivery head, and that the maximum value of the efficiency decreased as the nozzle pressure was increased. Higher nozzle pressures should be used when the delivery pressure is high, but low pressures are most efficient against low delivery pressures. (A. Bailey, British Air Ministry, Reports and Memoranda, No. 1545, Feb. 18, 1933, 27 pp. and 19 diagrams, abstracted from release by Press Section of Air Ministry, dated Oct. 6, 1933, *e*)

ENGINEERING MATERIALS (See also Machine Parts: "Compo" Porous Phosphor-Bronze Bearings)

Wear and Brinell Hardness in Bronze and Brass Castings

TO DETERMINE the relationship between Brinell hardness on one side and wear on the other, several worm wheels made of various materials were tested for side wear. These tests comprised runs on worm wheels of red brass of 76 and 106 Brinell hardness, a worm wheel of special brass of 130 Brinell hardness, and of forging bronze of 146 Brinell hardness. The tests were carried on in such a manner as to duplicate as nearly as possible the stresses occurring in practise, a steel worm having been used as a counterpart of the wheel. The best ability to resist wear was shown by a material with a Brinell hardness of 146 (forging bronze). This, after one million turns, has shown a wear of 0.25 mm (0.0098 in.). The material of 106 Brinell hardness (red brass) proved to be equally good and with the same number of turns a wear loss of 0.35 mm (0.0137 in.) has been determined.

The worm wheel made of special brass with a comparatively high Brinell hardness number of 130 showed, after 800,000 turns, a wear loss of 0.8 mm (0.031 in.). The worst showing was made by the red brass with a Brinell hardness of 76, which at 800,000 turns showed a loss of 0.9 mm (0.035 in.). From this data it would appear that Brinell hardness cannot be taken as a guide for measuring the wearability of metals and that there is no definite relationship between the two. (Based on tests by F. Brobeck, reported in *Giessereipraxis*, vol. 54, no. 29–30, July 23, 1933, p. 308, *e*)

Alkyd Resins as Bonding Materials

THE article begins by determining what a good adhesive should do and why a universal adhesive would be particularly desirable. As a rule, adhesives are made for the job instead of making the job work with a universal adhesive. As regards alkyd resin adhesives, perhaps the outstanding feature from the time of their discovery has been tackiness with subsequent adhesion to practically all materials, as well as a high degree of penetration of fibrous materials and good wetting action on surfaces. While certain alkyd resins have been well known for a long time, it was not until the advent of cheap phthalic anhydride that alkyd resins were considered for commercial purposes. Alkyd resins may be used as adhesives in insulation, for example, in mica products. Mixed with pyroxylin or certain plasticizers, these resins may be used to produce a quick-setting cement, for example, for labeling, pattern-shop work, and general office work. They can be used as a binder for foundry sand or a binder for molding materials.

Heat-convertible alkyd resins may be used without solvents as thermoplastic bonding materials. The literature of the subject and some patents are cited. (A. G. Hovey, General Electric Co., in *Industrial and Engineering Chemistry*, vol. 25, Industrial Edition, no. 6 (Consecutive no. 19), June, 1933, pp. 613–615, *p*)

Beryllium Alloys

BECAUSE of the fact that conflicting statements have been made as to the properties of alloys of beryllium with heavy metals, the following may be of interest.

A study of iron-beryllium alloys was carried out at the Bel Air Laboratory in Luxembourg by G. Kroll. He found that the presence of beryllium in iron alloys causes their hardening by aging which he explains by assuming that there is a glucinate of iron, the solubility of which in alpha and possibly in gamma iron varies materially with the temperature. The fact that the mechanical properties of beryllium-iron alloys change through aging seems to have been definitely established. The addition of nickel to beryllium-iron alloys produces particularly interesting results as it would appear that when the content of nickel is gradually increased, a decrease in the grain size is observed, and at a content of 4.77 per cent of nickel the structure becomes analogous to that of carbon steels. In this case, less beryllium is necessary to obtain the optimum effect of aging than in binary iron-beryllium alloys, namely,

1 per cent, as compared with 4 per cent. Alloys containing 1 per cent of beryllium and 5 per cent of nickel attained, after heat treatment and aging, a hardness which may be in excess of 600 Brinell. With the increase of nickel content from 5 to 22 per cent, the hardness produced by heat treatment followed by aging decreases very slightly, but when more than 22 per cent is present, this hardness rapidly falls off to about 200 Brinell. This is, however, affected to some extent by heat treatment.

In the case of quaternary iron-nickel-chromium-beryllium alloys, a different picture of hardness is obtained. In quaternary alloys containing 1 per cent beryllium, 5 per cent nickel and 20 per cent beryllium, there is a point in aging where the hardness is about 600 Brinell. Beyond that point the hardness decreases with aging. By changing, however, the content of nickel and beryllium to about 5 per cent of the former and 1.10 per cent of the latter and by changing the content of chromium at about 12 per cent of the latter, a new hardness point is obtained of the order of 680 Brinell. It would therefore appear that the presence of chromium enhances the effect of the nickel. It is also stated that where carbon is absent an excellent resistance to corrosion is obtained as well as some remarkable magnetic properties.

The remainder of the article is concerned with copper-beryllium and nickel-beryllium alloys, as well as light alloys. Some data are given as to costs. In the discussion which followed, the author stated that he obtained satisfactory results with additions of beryllium to cupra nickel. The beryllium is introduced in the form of a copper-beryllium alloy.

In answering a question as to the losses of beryllium when introduced into alloys, which have been stated by Renaud to be from 5 to 10 per cent, the author remarked that these were taken in 1931 from American practise and more favorable figures have since been cited by other investigators. The question of losses of beryllium in making up alloys is still considered to be uncertain. (Paper by J. Laissus, Managing Director of the General Laboratory of Industrial Testing, and P. Tyvaert, Chief Engineer of the same laboratory, before the French Technical Foundrymen's Association, preprinted in *Bulletin de l'Association Technique de Fonderie*, vol. 7, no. 6, June, 1933, pp. 209–219, 11 figs., *eA*)

FUELS AND FIRING

Proposal to Make Oil From Coal in South Wales

A COMMITTEE of experts has been set up by the Industrial Development Council of South Wales and Monmouthshire to examine a scheme for an oil from coal extracting industry in South Wales. Prof. George Knox and Doctor Illingworth, who are responsible for the plan, have now submitted details.

Capital totaling £7,500,000 would have to be raised with the support of local authorities and the Government. A central hydrogenation plant would be capable of producing 100,000 tons of petrol annually, using about 365,000 tons of coal, and providing permanent employment for 1000 miners and 1500 process workers. Construction of the plant would engage 15,000 men for a year. Other industries would benefit from the large orders placed for material.

Ten 1000-ton low-temperature carbonization plants would treat 3,650,000 tons of coal a year, producing about 240,000 tons of heavy oil, 40,000 tons of light oil, 70,000 tons of pitch, 3,220,000,000 cu ft of surplus gas, and 2,520,000 tons of smokeless fuel. These plants would employ permanently 4000 miners and 1400 process workers and their construction would absorb 12,000 men for twelve months. (*Industrial Britain*, no. 14, October, 1933, p. 7, *g*)

Elimination of Fusain From Coal

COAL consists of four main constituents: durain, clarain, vitrain, and fusain. The last of these is a dull brownish black constituent, present in the majority of coals to the extent of about 2 to 5 per cent, and more in some cases. It is usually very soft and friable, has a very high carbon content with low hydrogen and oxygen, as a rule has a high ash content, is devoid of coking properties, and has a high affinity for water. It is, therefore, from every point of view, an undesirable constituent, and if it could be separated by some cheap and convenient method, its absence would improve the coal and sometimes give it high-grade coking properties. The German Ore and Coal Flotation Co. (Erz und Kohle Flotation Gesellschaft), of Bochum, attempted to do this by froth flotation. This was first done by mixing more or less finely divided coal with about three to five or more times its weight of water, to which were added soluble froth-forming substances (such as acetone or cresol fractions from various tars), which diminish the surface tension of the water, together with traces of insoluble oil, such as ordinary kerosene, and bubbling air through. The result is to form a vast amount of froth which contains entangled the greater proportion of the coal particles, while the mineral matter is wetted and sinks to the bottom.

A colloid such as starch has to be added and there is where the trouble started. It was found that the process is extremely sensitive when starch is used as a colloid. Only about 0.25 lb is required per ton of coal. If a little too much starch or other colloid is used, a considerable amount of the valuable vitrain, clarain, and durain is not entangled by the froth and remains mixed with the fusain. If even a little too much colloid is added, a large proportion of the fusain remains in the froth which decreases the efficiency of the process.

According to a recent British patent No. 389,401 (1932) obtained by the same company, it is now claimed that if starch or dextrine is first pretreated with hydrochloric acid, inorganic chlorides, or organic-acid chlorides, and the product used as the colloid instead of raw starch or dextrine, then no action results on the vitrain, clarain, and durain, the fusain only being affected. Consequently, the process is no longer difficult of adjustment, since an excess of the colloid has no deleterious effect.

An example is given of 1000 grams of Ruhr coal slurry, having a 1:4 solid-liquid ratio, treated with 0.2 gram of dextrine pretreated with hydrochloric acid. After stirring for several minutes, three drops of pinewood tar fractions (creosote) boiling at 248 to 360 F (120 to 160 C) were added, followed by aeration. This removed the fusain, and the coal was then subjected to froth flotation with the addition of creosote and sodium carbonate to separate the vitrain, clarain, and durain from the ash. As a net result, there was obtained on the weight of the actual coal in the slurry 6.1 per cent fusain; 37.5 per cent high-grade coking coal (largely vitrain); 14.1 per cent middlings (largely durain); and 42.3 per cent mineral waste.

Another example given is that of 100 grams of an English coal dust of poor coking properties. This was stirred for several minutes with about three parts of water and 0.15 gram of starch pretreated with acetyl chloride, and subjected to froth flotation after adding four drops of acetone. As a result, the fusain was separated and the product then treated a second time with 0.3 gram of water glass (silicate of soda) and four drops of cresol, so as to separate the vitrain, clarain, and durain from the mineral matter giving 18.8 per cent fusain, 57.6 per

cent high-grade coking coal, 9.8 per cent middlings, and 13.8 per cent mineral waste.

In almost all cases the amount of pretreated starch or dextrine colloid used is only 1/4 to 3/4 lb per English ton (100 to 300 grams per 1000 kg), although in some cases up to 1.75 lb may have to be employed. The commercial stage with this process has, however, not yet been reached, and no claim is made to separate vitrain, clarain, and durain on these lines.

Reference is made to two other processes attempting to do the same thing. In the Lehman process, the coal is treated in a percussion mill so that the four coal constituents which vary in hardness are reduced to different states of subdivision and are separated to a greater or less degree by air currents. In the percussion mill so-called elastic percussion is used, the coal being broken up by a series of taps or relatively light blows, causing breakage chiefly along the natural lines of fracture. As a result, the coal is pulverized to a considerable degree, but not in the same manner as by ordinary grinding.

There is another British patent No. 186,143 (1921) relating to froth flotation with the addition of colloids such as starch, dextrine, glue, albumen, and tanin, together with such froth-forming constituents as cresol and kerosene. The difference between this and the 1932 patent referred to is not quite efficient, however. (David Brownlie, *The Steam Engineer*, vol. 3, no. 1, October, 1933, pp. 5–6, and p. 44, *d*)

Combustion of Pulverized Coal

ONE of the great difficulties in the study of processes of combustion of pulverized coal lies in the fact that in a furnace the conditions are not as a rule satisfactory for observation, while the minuteness of the size of the coal particle makes observation extremely difficult even under the best conditions.

The author claims to have developed a new method for the study of the process of combustion of pulverized coal and from results of the study, presents what might be called a new conception of the process of combustion which he supports by references to more or less well-established facts.

The particle of coal injected into a furnace obtains the oxygen necessary for its combustion from the air that surrounds it. The author assumes that the grain of coal remains all the time in the same atmosphere which was supplied to it at the instant it entered the furnace, or that, in other words, the velocity of the motion of the grain is the same as that of the motion of the gas.

He supports this hypothesis by pointing out that had the grain been moving slower than the gas, a part of the air would have remained unused, which is hardly likely in view of the very high content of carbon dioxide in the gases of combustion of pulverized-coal furnaces.

If, however, it is true that the coal and air move with equal velocity, then the process of combustion of a grain of coal may be duplicated by keeping both the grain and the atmosphere stationary, meaning by this latter term that they are stationary in space but may be subject to internal agitation. With such an arrangement, observation of the process of combustion becomes materially easier than is the case where the grain of coal is in motion.

The author proceeds further and asks how the combustion of a grain of relatively large dimensions, for example, 1 cu cm, differs from that of a grain only a few microns in diameter that is usually the size in burning pulverized coal. The sequence of phenomena ought to be the same though their duration will naturally be different. The author therefore considers it feasible to derive the loss of combustion of powdered coal of usual dimensions from that of the combustion of large grains. He does not claim that with the combustion of the large grain conducted in a confined atmosphere the two are identical, but he believes that an observation of the combustion of the large grain may give useful information as to the conventional process.

Let us then, he says, take a lump of coal of some such diameter as 1 cm and burn it by suspending it in the atmosphere of a little electric furnace kept in a horizontal position as so to eliminate the circulation of the gases. The little lump of coal is held by a long pair of pliers electrically grounded. Under these conditions there is first a period of waiting, during which the particle of carbon heats up and finally discharges a smoky gas which immediately ignites and burns with a white flame. At the same time there are seen to form around the grain long, floating, branched streamers. This indicates that certain of the hydrocarbons have been decomposed into hydrogen which produces the white flame and carbon which constitutes the soot. Finally, nothing is left of the lump of coal but a piece of partly coked carbon with a hair-like cover of soot at red heat.

The second phase of combustion then takes place, during which the soot and the coke burn simultaneously. The soot burns with considerable difficulty, and the hotter the furnace the faster it burns. The moment the piece is removed from the furnace the soot becomes black, while the coke retains its incandescence for an instant. Gradually, the soot formations disappear and only the coke is left. This is then red hot and is surrounded by a blue zone extending for a short distance from the piece. The brilliancy of the carbon piece is then gradually dimmed, and its diameter decreases until the piece disappears as a brilliant point in the center of a mass of ash, suddenly going out.

In this process of combustion several complicated phenomena have taken place, as to the nature of which there is as yet no common agreement. The process of combustion of a little lump of coal, be it of more or less substantial dimensions or a few microns only, may be, in a simplified form, broken up into three stages: (1) precombustion, during which the evolution of gas takes place, the moisture in the coal disappears, and the carbon is heated; (2) combustion of the hydrogen generated by the decomposition of the gases; and (3) simultaneous combustion of coke and soot.

In considering each step separately, the author calls attention to the fact that the period of precombustion varies with the coal and the nature of its hydrocarbons, as well as the facility with which gases are generated from it, and the "ignition point," which is, therefore, in the nature of a physical constant such as the fusion point. The velocity of the heating of the coal may also have an influence on the evolution of greater or lesser masses of gas. The influence of the partial admission of air at the entrance to the boiler is also a well-known factor.

As regards the simultaneous combustion of coke and soot, it is pointed out that the gases which burn first heat the coke and gradually bring it to incandescence. This part of the combustion process is probably less easy to understand than any other. Some chemists claim that atomic hydrogen produced by the decomposition of organic matter is the first to ignite, while others claim the earlier action of tar vapors. The author limits himself to having established the fact that the gases burn first, and points out that the combustion of these gases requires only a small amount of air as compared with the total air required for the combustion, and that therefore it is unnecessary to introduce the whole area at the beginning of combustion.

He also claims that in this first stage of combustion turbulence can only make trouble by detaching the jacket of burning gas from the particle of coal. The turbulence-producing burner can, therefore, do more harm than good, providing its functions are not limited to the production of intimate mixtures of air and coal. In fact, it may at the very beginning of combustion create an agitation in the gas, the effect of which will be to blow out the flame around the coal particle just as one blows out a candle.

The coke in the coal burns just about the time that the white flame goes out. At that instant and shortly thereafter the gases continue to be evolved in gradually decreasing quantities. The presence of the blue halo around the particle of the coke leads one to believe that carbon monoxide is first to form because the quantity of oxygen in immediate contact with the grain of coal is insufficient to secure immediate combustion to CO_2. The amount of air available is all the smaller because of the tendency of the gases to expand and because of the presence of ash. It is only by subsequent diffusion in the atmosphere of the furnace that the hot CO finds the oxygen necessary to burn to CO_2. This is in close agreement with the definition of combustion given by Professor Aufhaüser, namely, as producing H_2 and CO.

The soot burns at the same time as the coke and follows, therefore, the same process of combustion. Everything indicates, however, that this combustion does not proceed as easily as that of the coke because it is not assisted, as in the case of the latter, by the presence of residual gases, and requires a much higher temperature. The least cooling below 700 C (1292 F) extinguishes the soot. It is because of the presence of the soot that the combustion chambers of boilers burning rich coals have to be much larger than those burning lean coals (that is, low in volatile matter). The long white flame of the former is due to the burning of gas containing soot. As soon as this flame touches a comparatively cold surface, it deposits lampblack there. This also explains why pulverizing does not have to be carried as far with bituminous coal as with anthracites. As a matter of fact it does no good to have the coke burn up before the soot does.

The author then comes back to the combustion of the experimental lump of coke. As it burns in the meager air atmosphere that has been provided for it at the start, it pollutes this atmosphere by the admixture of its own carbonic gas, which forms a kind of jacket around the lump opposing the access of oxygen. It is at this stage of the process that it becomes necessary to stir up the gas in order to facilitate the diffusion of the carbon monoxide and the eventual liberation of the ash. Even with these measures the atmosphere becomes more and more polluted, and consequently, as the burning particle approaches the exit to the smokestack, combustion becomes more and more difficult. It is at this moment, that is, at the beginning of the combustion of coke, that turbulence is helpful, and this may be produced by the introduction of the secondary air.

Because of the decrease in density at the increase in viscosity of the hot gases, the turbulence created at the burner dies out. Moreover, at this stage the coke has been heated to a red heat and agitation of the air does not tend to blow out the flame. Finally, the temperature of the furnace has fallen off, but turbulence may help to maintain the coke in a state of incandescence in exactly the same manner as a spark escaping from the furnace continues to burn because of its rapid motion through the air.

The author claims next that his hypothesis that coal and gas move in the furnace with the same speed makes it possible to determine the equation of the combustion space. In doing this, he uses some data presented by Professor Damour in the December, 1932, issue of *Chaleur et Industrie*. This formula is as follows:

$$\text{Volume} = V_0 K t/3600$$

where V_0 is the volume of air per kilogram of coal at the temperature prevailing in the furnace, K the hourly consumption of the furnace in kilograms of coal, and the t duration of combustion of the largest grains of coal. The only unknown here is the duration of combustion, which, together with V_0, the author proceeds to study.

As regards the duration of combustion, the author refers to the work of Audibert, who showed that present combustion chambers are bigger than theoretically they should be. He has shown, for example, that grains of semi-coke 65 mm in diameter took 0.2 sec to burn in a chamber, having a temperature of 1400 C (2552 F) and 40 per cent excess of air, whereas it took 0.28 sec under the same conditions to burn a grain of bituminous coal. He has also shown that the ratio between the duration of combustion of grains of 65 and 120 microns is as 2 is to 3.

To apply the formula it would be necessary to note the duration of the combustion of grains of various diameters, and if one followed Audibert, it may be extremely difficult to determine it, as special investigations would have to be made for every grain size and for every kind of coal. The author has therefore started to search for a more general, though less scientific, method to solve this problem, and has developed such a method based on the assumption that if cubical grains of coal are assumed, the decrease of the dimension of the size of the cube in the course of combustion will be independent of the original size of the cube. The experimental demonstration of this assumption is based on the hypothesis previously stated, namely, that if this principle is correct for a measurably grain, such as a cube 10 mm on a side, it will be correct also for powdered coal.

With this theory, a series of experiments were carried out in a little electric furnace of the fuels and firing laboratory of the Conservatory of Arts and Crafts (a technical school of high standing in Paris). Grains of carbon, possibly of a kind that would not burst into flame, have been made and the weight divided by the density, whereupon the cube root of the volume was determined. This gave the side of the cube of coal having the same weight as the grain tested. A certain number of these grains of different weights were then located on a small ceramic plate and placed in a furnace previously heated to the desired temperature. At the end of a certain period of time, all the grains were taken out at once, whereupon each was weighed and its volume and the length of the side of the cube it represented were caculated in the same manner as before, which gave the difference between the original and the final dimension for each grain. These experiments were repeated many times, varying the duration of combustion and temperature.

At first glance the results appear surprising, but the author considers them strictly logical. Let us consider a piece of coal 1 cm thick, to both sides of which a flame is applied. Assuming that combustion has been the same throughout, the piece of coal will diminish uniformly in thickness. If the piece of coal is divided into a number of unequal parallelepipeds of equal thickness, the result will be the same. The piece of coal will simply have become a collector of grains of different sizes burning on the two opposite faces, and one dimension in all of these grains will decrease equally for all of the grains at the same time. If, now, the grains are separated so as to permit them to burn on all of their faces, the other dimensions will

decrease equally and in the same manner. There is one objection to this reasoning and that is that in a powdered-coal-fired furnace the large grains ignite later than the small grains as it takes them a longer time to become heated. Considering, however, the poor heat conductivity of coal, this source of error, while present, may be considered as negligible, and Audibert, for example, paid no attention to it. The author assumes, therefore, that in an actual furnace heated with pulverized coal all the grains decrease in diameter simultaneously and to the same extent, since in each particular zone of the furnace they are subjected to the same condition, both with respect to temperature and to the condition of the atmosphere. All of this is, of course, assuming that the grains move at the same speed as the air which is carrying them. From this it follows that by the time grains of 20 microns have burned up completely, all the bigger grains have decreased to the extent of 20 microns, so that grains which were originally 100 and 120 and 130 microns in diameter are now only 80, 100, and 110 microns. (Adrien Biraud, *Chaleur et Industrie*, vol. 14, no. 157, May, 1933, pp. 209–217, 6 figs., *tA*. Only the first part of the article has been abstracted; the remainder will be presented later, if and when space is available.)

GAS ENGINEERING

Improved Tully Gasification Plant

THIS is a description of the Tully plant installed at the works of the South Oxfordshire Water and Gas Co., at Goring-on-Thames. All Tully gas at this plant is sent out without enrichment or admixture of any kind. A large percentage of the gas produced at Goring is used in the gas engines actuating the high- and low-pressure pumps of the water works and its performance is said to have been entirely satisfactory in these engines. In the incandescent mantle the gas gives a very bright light, the whiteness of which compared with that from ordinary coal gas is very noticeable. The gas generator has an automatic poker in the retort section, its function being to facilitate the downward movement of the fuel and also to improve the carbonizing conditions within the retort, thereby insuring that the coal shall be effectively coked before it reaches the lower or gasification section of the generator. The grate is of the usual fixed type but is provided with an ash rake automatically operated for continuous removal of the ash, clinker, and refuse.

On the waste-gas outlet of the generator is a horizontal multitubular waste-heat boiler, the steaming capacity of which is sufficient to provide all the steam required for driving the blower and operating engines and also for gas making in the generator. Consequently, there is no independent boiler to stoke, and as the waste-heat boiler is provided with an automatic feedwater regulator, no labor whatsoever is needed for steam raising. Although the plant is worked for only one shift per day, no difficulty is experienced in starting up the waste-heat boiler being designed to maintain an ample steam pressure over a long shutdown period.

The patented mechanical operator opens and closes cycle after cycle all the operating valves of the plant, insuring in each cycle the correct duration of both "blow" and "run." The operator consists of a single intermittently rotating camshaft to which all the operating valves of the plant are positively connected in such a way that they can only be opened and closed in the correct sequence. One complete revolution of the camshaft suffices for one cycle of operations, the duration of each period of the cycle being controlled by a positive acting selector gear which can be set to give the desired working cycle. (Walter T. Dunn, *Gas Journal*, vol. 203, no. 3760, Sept. 20, 1933, pp. 620–622, illustrated, *d*)

HYDRAULIC ENGINEERING

Corrosion and Cavitation

THAT, under certain conditions, cavitation on hydraulic-turbine rotors produces corrosion has been known for a long time. The present author investigates this process in detail. In his tests he paid particular attention to the observation of the process of initiation of corrosion. He found that this is difficult to observe, but the next step in the process of corrosion, namely, the formation of holes, occurs with great suddenness. The holes of about a fraction of a millimeter in diameter appear first individually, but very rapidly extend over the entire region affected and grow in size as they extend. Because of the fact that it is easy to observe and also because it is the indication of the loss of material of the blade, this stage is called "initiation of corrosion" by the author. This initiation appears to be a function of the water velocity v when the pressure distribution in the diffusor is constant. From the author's tests it would appear that once the small velocities are passed, the increase in the period of initiation varies exponentially. Above a certain critical velocity, characteristic for a given material, a very rapid destruction is observed, the curves varying at times constantly and at times by jumps. The total amount of corrosion has been determined by the author from the loss of weight. The relation between corrosion and the hardness of the material was shown by the different degree of resistance of several kinds of bakelite of different hardnesses. Thus, a plate of bakelite *C* was completely destroyed in a couple of hours, while a plate of another harder material showed practically no attack after ten hours. From this the author proceeds to a discussion of what he calls the "velocity of progress of corrosion." To determine this he uses the data obtained by determining the total amount of corrosion by measuring the loss of weight. He takes the volume of material lost and divides it by the area of the cor-

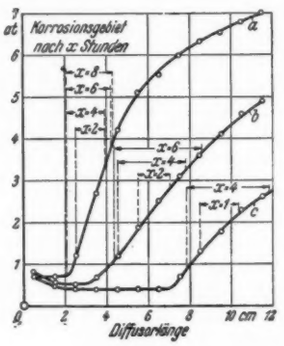

FIG. 1 CURVES OF PRESSURE DISTRIBUTION SHOWING THE REGIONS OF CORROSION (LEAD)

(Velocity of flow of water v = 44 m per sec; a = the smallest hole observed; b = average holes; c = the largest hole observed. Ordinates, atmospheres; abscissas, lengths of diffuser; two lines of German in the upper left-hand corner mean region of corrosion after x hours.)

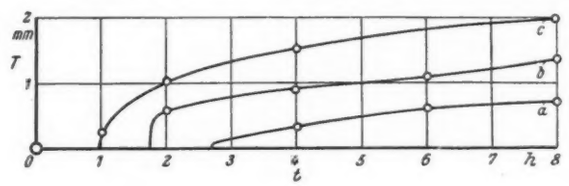

FIG. 2 DEPTH T OF A CORROSION HOLE IN LEAD AT ONE POINT x WITH VARIOUS PRESSURE DISTRIBUTIONS a, b, AND c, FIG. 1 (v = 44 M PER SEC)

roded surface, obtaining in this way the average thickness of the layer carried away by corrosion. Noting the time that this took, he obtains an average velocity of corrosion measured in terms of depth of material affected. The magnitude of this in relation to time can be determined experimentally. Further experiments have shown that the velocity of progress in corrosion depends on the character and magnitude of the holes. Fig. 3 shows the loss of weight as determined by measurement with three kinds of pressure distribution.

It has been found that as the formation of the holes increases, not only the corroded area increases but also the velocity of corrosion, as shown in Fig. 2. Further measurements with different angles of diffusers have indicated that corrosion increases with the increase of angle. Further experiments with built-in weirs, cylinders, etc., have shown that corrosion is a function of the character of formation of the holes. It would appear, therefore, that corrosion as such, according to the test described here, is a function of the coefficient of material ΣK_M, of the velocity of flow of water v, and constants written as K_H, these constants depending on the particular circumstances and the magnitude of the hole formation. To this must be added the original functional relation to the surface of the material, as well as the factor of admixtures to the water, in particular, its air content.

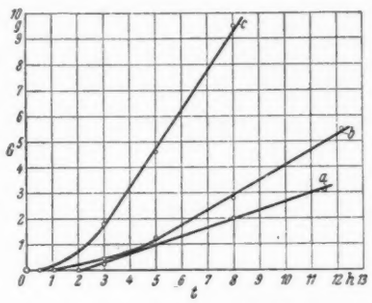

FIG. 3 LOSS OF WEIGHT G OF LEAD ON THE SURFACE OF THE CORRODED MEMBER AT VARIOUS EXTENSIONS OF THE HOLES

(Compare Fig. 1; v = 44 m per sec.)

This factor still needs investigation. The following general formula is cited:

$$K = F_{(\Sigma K_M, v, K_H, k_0, K_W)}$$

Such factors as roughness of surface are also discussed. The conclusion to which the author comes is that a further investigation of the subject is necessary. (H. Schröter, communication from the Kaiser Wilhelm Institute for Research on Flow, Göttingen, published in *Zeitschrift des Vereines deutscher Ingenieure*, vol. 77, no. 32, Aug. 12, 1933, pp. 865–869, 22 figs., *e*)

Leyland Motors Hydraulic Torque Converter

THIS converter was shown at the Commercial Motor Transport Exhibition at Olympia, London, opening on November 2, 1933, as applied as an alternative transmission system to the conventional clutch and gear box in motor coaches and omnibuses. Driven by the engine, there is a rotor in shape much like the impeller of a centrifugal pump. Partly surrounding the impeller is the rotor which is connected to the road wheels, and upon which are mounted three rows of blades not unlike those of a steam turbine. The casing into which these two parts fit carries two rows of fixed blades which guide the hydraulic fluid on to the blades of the rotor. The hydraulic fluid follows a closed path, being driven outward by the impeller and traveling inward through the blades of the rotor. Its pressure varies from about 25 lb per sq in. at the center to about 50 lb per sq in. at the outside. Although this converter is a form of hydraulic coupling, its design is different from that of a fluid flywheel. The latter is constantly in use while this converter is not, being cut out of action when a certain optimum speed is reached (direct drive).

The original article shows a graph showing the acceleration obtainable with an ordinary gear box and with a torque converter on a Titan type of omnibus. An optimum speed of 20 miles has been selected, and for greater speeds a clutch mechanism is provided by the use of which a direct drive may be obtained. This clutch mechanism is described in the original article.

The most serious difficulty inherent in the design is that leakage of fluid from within the converter may take place. Since the pressure of the oil within the converter may rise in the central space to 25 lb per sq in., special precautions are necessary. To prevent the oil from leaking out through the clearance between the impeller and rotor to the space around the central shaft and thence escaping longitudinally along that shaft, a copper bellows gland is fitted between the two rotating parts. Similar copper bellows glands prevent the oil from escaping from the spaces behind the rotors along the outer surfaces of the sleeves. It is impossible, however, to prevent leakage altogether, nor in the interests of lubrication would it be desirable to do so, and special passages are provided in the casing to collect any oil that does escape. A reserve oil tank is mounted on the dashboard of the chassis, and the leakage oil is conveyed to this tank by an injector, the high-pressure oil for which is obtained from the pressure side of the converter. A similar injector forces the oil from the reserve tank back into the spaces behind the rotors of the converter. Road tests of the Titan chassis fitted with one of these converters are described. (*The Engineer*, vol. 156, no. 4057, Oct. 13, 1933, pp. 362–363, illustrated, *d*)

Supervisory Control and Automatic Protection in Hydroelectric Developments

AFTER briefly sketching the history of supervisory control and automatic protection, which is of very recent origin, the author describes the operation of the synchronous-selector supervisory system which has been adopted in the Mersey properties in Nova Scotia. Several other types besides the one used in the Mersey system are described, the Mersey requiring four wires for its operation. The details of operation are given and the possibilities of its application are indicated. Just to show what the system can do, the following list of requirements is given:

(1) To start and stop two waterwheel-driven generators in each of the two remotely located stations, and two similar units remotely located in the same station.

(2) To raise and lower the voltage on all of these machines.

(3) To open and close the governors of all these units for a division of the load.

(4) To operate a bypass gate in the No. 1 dam in order to balance the water below in the event of a unit's being out of service for any reason.

(5) To tie in the units automatically.

(6) To get a satisfactory number of readings of the water elevation at No. 2 dam so that efficient and continuous operation of that power house as well as No. 3 power house will be assured.

In addition to this the units are so equipped that they will automatically take care of themselves in the event of certain irregularities. The whole development scheme on the Mersey River has been laid out in such a way that if it is economical to

do so, future developments on the Medway River can be controlled as well from the same point.

The success of the Mersey system to date is considered as phenomenal. In general, supervisory control is intimately connected with automatic protection, and in small installations, practically its sole value is, in the author's opinion, tied up with automatic operation. In the design of larger stations, automatic protection is applied because it is justified in the better protection given to the equipment, often saving thousands of dollars in loss when accidents occur, sometimes due to human failures but often due to machine failures which cannot be detected by the attendant until after the permanent damage has been done. In the application of supervisory, therefore, to a larger installation, or to switching operations only, the benefits may be chiefly speed in and ease of control of a complicated system, which in themselves are extremely important in a large system, and easily justify the outlay. In the smaller systems, however, the supervisory cannot be economically applied unless the cost of station attendance is reduced thereby. Following this train of thought, it can readily be seen that applications will present themselves where the automatic protection is justified but where supervisory control is too expensive.

On the Mersey, the direct saving in operating labor of at least $12,000 a year was made, while the maintenance costs have not exceeded those of manual stations for the same period of time and under the same conditions.

There is another possible application in Nova Scotia which would apply to very small stations where, as mentioned above, it would not be justifiable to install supervisory control but where automatic protection of the units could eliminate the attendants entirely and thus greatly reduce the cost. By doing this, many small power sites can be used which could not be economically developed by other means. There are many cases in Nova Scotia where small tributary streams can be made available as supplementary supply to the main station, either on a peak-supply basis, a run-of-the-river basis, or a straight energy basis. These small stations will usually be in comparatively inaccessible places and the design of the building need only be such as to make a fireproof, rugged structure which will be correspondingly cheap. The value of many of these small developments can be better realized when it is considered that a 100-kw generator operated continuously will deliver at its own switchboard probably 800,000 kwhr a year after allowing for some time out of service. At the same time the loss of that 100-kw unit at any time will not affect the peak-carrying capacity of the system. In a case of this kind supervisory control would certainly be a needless expense, but a very satisfactory scheme would be to simplify the generating stations to the utmost, even to the elimination of a voltage regulator, with the excitation system so designed that even at runaway speed, dangerous voltages would not exist. In this case governing could also be eliminated, provision being made only to close and open the gates. Automatic devices in this case would only be required for oil temperatures, field failures, and one or two other such contingencies.

It is rather difficult to deal in costs without using specific cases, but an attempt will be made to show that a small installation as just described would be economic. As an overall cost, it can be fairly assumed that $200 a kva would cover the installation, so that the total would be $20,000. Taking fixed charges and maintenance at 10 per cent, the annual cost would be $2000, which would cover all costs. This gives a cost per kilowatthour of 0.25 cents, which is certainly very cheap energy. If this station were attempted on a manual basis, the cost of operation alone, even with attendance of a type comparable with the importance of the station, would be probably $1500 a year, to which must be added the cost of housing for its staff which would likely bring the cost to $2000 for operation only. In other words, the addition of a few automatic features would cut the cost of energy at this station by 50 per cent and give adequate protection to the installed plant. It might fairly be argued that an installation as small as this could be operated unattended and unprotected and take the risk, but that cannot be considered as comparable to the condition of operation that would exist under the protected conditions with the risk eliminated. (Howard Fellows, Asst. Ch. Engr., Nova Scotia Power Commission, paper presented at the Maritime Professional Meeting of the Engineering Institute of Canada, July 13, 1933, published in the *Engineering Journal* (Journal of The Engineering Institute of Canada), vol. 16, no. 10, October, 1933, pp. 417–422, 4 figs., *dA*)

INTERNAL-COMBUSTION ENGINEERING

Sirron Pressure-Charged Diesel Engine

THIS unusual type has been developed by the Newbury Diesel Engine Co., Ltd., to meet the requirements of motor coaster type of vessels. It is a two-stroke single-acting unit of the trunk-piston type and its special feature is the use of rotary blowers in order to obtain the high mean effective pressure required. Another somewhat unusual feature is that the exhaust-port opening is controlled by rotary valves (under license from the Still Engine Co.), these valves being located between the exhaust port and the manifolds.

There is a separate rotary blower for each cylinder, chain-driven at twice engine speed. The brake mean effective pressure in the commercial design is rated at 70 lb per sq in. and in the special design, 82 lb per sq in. It is said that the first engine of the class constructed has been tested with very much higher mean effective pressure than specified. (*The British Motorship*, vol. 14, no. 163, September, 1933, pp. 198–200, 5 figs., *d*)

Increasing the Air Charge and Scavenging the Clearance Volume of a Compression-Ignition Engine

THE object of the investigation presented in this report was to determine the effects of increasing the air charge and scavenging the clearance volume of a four-stroke-cycle compression-ignition engine having a vertical disk form of combustion chamber.

Boosting the inlet-air pressure with normal valve timing increased the indicated engine power in proportion to the additional air inducted, and resulted in smoother engine operation with less combustion shock.

Scavenging the clearance volume by using a valve overlap of 145 deg and an inlet-air boost pressure of approximately $2\frac{1}{2}$ in. of mercury produced a net increase in performance of clear exhaust operation of 33 per cent over that obtained with normal valve timing and the same boost pressure. The engine tests indicate that, with a large valve overlap, $2\frac{1}{2}$ in. of mercury boost pressure is sufficient to scavenge completely the clearance volume, and that the increase in engine power effected by scavenging the clearance volume, for a constant fuel quantity, is more than twice what could be obtained from the additional air charge alone. The improved combustion characteristics result in lower specific fuel consumption and a clearer exhaust. The starting and idling characteristics were not affected by variation in boost pressure or by the use of scavenging with a large valve overlap.

Analysis of the exhaust of several compression-ignition engines showed the carbon-monoxide gas content to be less than one half of 1 per cent when operating with a clear exhaust. (J. A. Spanogle, C. W. Hicks, and H. H. Foster, in National Advisory Committee for Aeronautics, Report No. 469, 1933, pp. 3–12, 13 figs., *e*)

Brooke 80–130-Hp High-Speed Marine Oil Engine

THIS engine, built by Brooke Marine Motors, Ltd., Adrian Works, Lowestoft, England, is remarkable in that it has been designed for continuous running at speeds approaching 2000 rpm, which is high for airless-injection engines of this size. At present, two models are contemplated—a four-cylinder model with a bore of 108 mm (4.25 in.) and a stroke of 146 mm (5.75 in.), and a six-cylinder unit with a bore of 115 mm (4.52 in.) and a stroke of 142 mm (5.59 in.). The six-cylinder engine is essentially the Associated Equipment Company's 130-hp road-vehicle engine modified to render it suitable for marine use. The road engine has been run on occasions at more than 3000 rpm.

The six cylinders are in the form of a monobloc casting with two cast-iron heads, each covering three cylinders. The marine engine has a heavier flywheel than the road engine. The original article gives data as to some of the details, such as lubrication and water cooling. The marine unit complete with reverse gear, electric starter, and exhaust manifold weighs 2300 lb with cast-iron bottom half of the crankcase and reverse-gear casing, and 2100 lb with aluminum-alloy castings. (*Engineering*, vol. 136, no. 3534, Oct. 6, 1933, pp. 385–386, *d*)

Kincaid Two-Stroke Diesel Engine

THIS is a two-stroke single-acting motor built under the Burmeister-Wain patents. It has piston exhaust valves and a straight-through scavenge of air, and will be installed in the motor passenger and cargo ship *Malaita*. At 110 rpm, the output is 1750 bhp, though the engine is required to be capable of maintaining 25 per cent in excess continuously if necessary. The scavenging air pumps are driven by a triplex chain from the crankshaft.

The eccentric rods each have a beam at the upper end, to which are coupled two actuating rods, passing through guides and secured to inclined rods which extend to an athwartships yoke. The yoke is, in turn, fixed to the piston valve. These upper rods owe their inclination to the fact that the eccentric on the crankshaft is necessarily out of line with the axis of the cylinder and, accordingly, with that of the piston valve. The main piston leaves the scavenging-air ports uncovered at the bottom of the stroke, the piston valve having risen to open the exhaust ports.

The scavenging-air ports are arranged in a ring around the liner, and the air passing into the cylinder receives a whirling motion, giving a complete rotary scavenge effect. There are 18 ports, and all are machined out of the solid metal. They are 54 mm in width. The liner is in two parts, the upper portion having a weight of 290 kg (about 640 lb) while the lower part, in which are the ports, weighs 370 kg, or approximately 815 lb. It may be added that there is a sleeve in the lower part, fitted with a set of rings which bear round the skirt of the piston.

The speed of the circulating fresh water through the inlet and outlet branches is 3.179 fps and the speed of the salt cooling water is 7.28 fps; the speed past the cooler tubes is 2.13 fps for the fresh water and 1.325 fps for the salt water.

In the oil coolers the speed of the lubricant through the inlet and outlet branches is 3.27 fps and the speed past the tubes 1.78 fps. The speed of the water through the inlet and outlet branches is 7.54 fps; that of the water through the tubes is 1.28 fps. The estimated quantity of cooling water in use on the test bed was provided with a cooling pump driven by a 15-hp Royce electric motor having a speed of 400 rpm to 600 rpm.

The detail of the scavenging blower design including the reversal valves is given in the original article. The same applies to the fuel pump and atomizer. A thimble-tube Clarkson boiler is used to recover the heat from the exhaust gases. (*The British Motor Ship*, vol. 14, no. 163, September, 1933, pp. 191–193, 4 figs., *d*)

Lorenzen Floatless Carbureter

THIS carbureter, designed by Christian Lorenzen, was introduced in Germany under the auspices of the German Aviation Research Institute. Several sizes have been built, including large units for aircraft engines and smaller ones for motor vehicles.

Fig. 4 shows the carbureter in section. The casing has a circular opening in the top, concentric with the perpendicular axis of the mixing chamber, and into this is inserted the work-

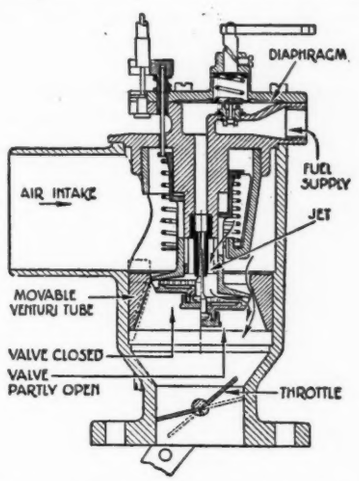

FIG. 4 LORENZEN FLOATLESS CARBURETER

ing mechanism. The top of the casing contains a flat chamber, partially subdivided by a horizontal wall, and provided with a cover having in the center a cylindrical dome with a small coil spring pressing on a diaphragm of doped silk, the center of which is reinforced by a small metal disk. From this hangs a short stem terminating in a small piston which slides inside a correspondingly small cylinder passing through the horizontal wall. This wall partitions off a chamber connected with the gasoline supply pipe. The small cylinder projects on both sides of the partition and in the projecting ends are several longitudinal cuts.

When the diaphragm is depressed fully by its spring, the metal disk lies on top of the upper cylinder rim, while the small piston partially uncovers with its upper edge the slots in the lower. Thus fuel can flow up through the cylinder into the diaphragm chamber. The diaphragm can execute a stroke only 1 mm long, and as it abuts in its top position against the lid, and in its bottom position against the cylinder rim, it is subjected to practically no strain.

Integral with this casting is a hollow cylindrical boss projecting perpendicularly downward and terminating in a long

jet, inside a cylindrical chamber turned out of the lower end of the boss, and provided with ports. A hollow mushroom valve is free to move axially on the cylindrical boss and is suspended by a coil spring, so that when the engine is not working, its head completely closes the constricted section of the venturi tube. Thus the mixing chamber is virtually cut off from the air inlet chamber, which completely surrounds the stem of the valve. All around its rim the hollow valve has a large number of orifices, opening toward the mixing chamber, and, standing upright in the center of its bottom plate, it carries a long tapered metering needle, which projects inside the jet.

When the valve is closed, the needle completely obstructs the jet orifice. The fuel entering the diaphragm chamber fills this and the bore, as well as the jet, whereupon the diaphragm shuts off further fuel supply. The stem of the valve is furnished with ports, the lower edges of which, in the closed position, just miss the top edges of the ports in the cylinder surrounding the jet.

As soon as the engine is started, the suction slightly draws down the valve—so that its ports begin to coincide with those of the jet cylinder—and, with it, the needle, allowing fuel to pass through the fine annular space formed between it and the jet rim. This runs down on to the bottom of the valve.

Through the orifices in the periphery of the valve the engine draws air, so that a powerful air current is generated inside the valve, coming in through the ports. This, passing over the bottom plate, picks up fuel particles. An intimate mixture of these with the air is thus brought about and a rich fuel-air spray emerges from the orifices, where it is caught at right angles by another powerful air current which enters between the still-constricted portion of the venturi tube and the valve rim on account of the latter's being slightly drawn down into the mixing chamber.

Owing to the great number of orifices, from which fuel-air spray emerges, relatively small air velocities suffice to cause practically instantaneous and complete vaporization. Indeed, vaporization is such that, even on a warm summer day a freezing temperature is generated in the mixing chamber, if the air is not preheated.

It is claimed that the loss of pressure in this carbureter is on the whole less than in normal instruments, because the air velocity of only 260 fps completely vaporizes the fuel spray. (*The Commercial Motor*, vol. 58, no. 1484, Aug. 25, 1933, pp. 53–54, 2 figs., *d*)

Petter A.C.E. Diesel Engine

THIS engine has been developed as a power unit for land and marine propulsion and is made in two sizes, a three-cylinder industrial model and a four-cylinder marine engine, both having the same cylinder bore and stroke, namely 115 mm × 136 mm (4.52 in. × 5.35 in.). It has been adopted by Shefflex Motors, Ltd., as a power unit of their three-ton truck. Its maximum brake mean effective pressure at 1000 rpm is 50 lb per sq in. and its maximum brake horsepower is 50, delivered at 1750 rpm. The engine operates on a two-stroke cycle and has no valves in the combustion chamber. An unusual feature is that instead of employing crankcase compression for scavenging, a separate scavenge pump is used for each cylinder. It is claimed that this insures a good scavenge air velocity and a high volumetric efficiency without the risk of lubrication troubles often encountered in two-cycle engines. The absence of valves permits an exceptionally clean design of the combustion chamber which, in turn, aids scavenging. The further advantage attending the absence of valves is the unrestricted water passage made possible with the consequent uniform cooling of the head. The sprayer, being water-jacketed, is less likely to become covered with carbon externally.

Situated on the off-side of the engine, the scavenge pumps are of slightly larger capacity than the power cylinders. The details of construction and cycle of operation are given in the original article. (*The Automobile Engineer*, vol. 23, no. 310, September, 1933, pp. 317–318, 4 figs., *d*)

Monovalve Marine Diesel Engine

THESE Diesel engines use only one valve per cylinder, which makes it possible to utilize L-head construction, and to alter the shape of the combustion chamber so as to adopt it to direct-injection Diesel practise. The use of a single valve port cylinder is applicable only to a Diesel engine where nothing but clear air enters the cylinders on the intake stroke. On the exhaust stroke of the piston the exhaust gases issue through the valve port at a very high velocity which tends to create such an intense vacuum throughout the intake manifold adjoining it that there is practically a clear air seal set up within the venturi construction of the manifold.

It is said that on the intake stroke of the piston the valve remains open and the stream of inrushing thin air is merely deflected slightly to another valve port.

It is stated that the engine weighs less than 20 lb per hp and that the fuel consumption is 0.44 lb per hp-hr. It is also stated that the torque curve of this engine is so flat and the fuel combustion so complete that it is practicable to run this engine over a speed range of from idling to 2000 rpm and still get a clear exhaust and a fuel consumption of less than 0.5 lb per hp-hr. (*Pacific Marine Review*, vol. 30, no. 10, October, 1933, pp. 306–307, 3 figs., *d*)

LUBRICATION

The Effect of Metallic Lead Dope on the Carbonization of Oil in the Combustion Space of an Engine

DR. R. O. KING, together with Callendar and Mardles, obtained British patent No. 295,230 for improvements in or relating to lubricating oils. Their process consists in controlling the oxidation of lubricating oil to delay the formation of carbonaceous products by introducing into the oil small amounts of tetra ethyl of lead or similar metallic dopes.

Briefly, they found that oxidation of oil is delayed by this method and engine performance with doped oil is improved. In tests on a motorcycle engine it was found, at the end of 500 miles running, that a thin film of carbon formed on the cylinder head, substantially in the same amount as with undoped oil. The carbon, however, was easily flaked off with the finger nail, whereas a chisel was needed to remove that found after using undoped oil. The piston head was free of carbon except on the vertical portion of the deflector facing the transfer port and spark plug. One of the most interesting parts of the paper deals with photographs of bottles containing the various oil samples.

Two groups of photographs are shown in the original article. In the first group the bottles were placed in front of openings cut in a black mask behind which is a sheet of Bristol board carrying black bands drawn with India ink. The light is placed behind the Bristol board. It is impossible to see the black and white bands through the used oil by the eye and they do not show in the photograph taken on a panchromatic plate and using a colored filter, but the bands appear plainly on the photograph of the same samples taken by infra-red light. Only the aggregations of carbonaceous matter are opaque to the infra-red light, thus the progress of settlement is shown, the oil increasing in transparency toward the top

of the bottle, the pile of carbonaceous matter which has settled out showing clearly at the bottom. The oil samples had been standing undisturbed for five years. It will be noticed that with either method of photography, the used dope oil and the fresh oil are almost equally transparent, the difference, if any, being in favor of the former. Although no oxidation products could ever be seen in the used dope oil by transmitted light, a small quantity of sludge of a gelatinous nature settled out during the five-year period, and is just noticeable at the bottom of the bottle photographed by infra-red light. (R. O. King, *Engineering*, vol. 136, no. 3528, Aug. 25, 1933, pp. 183–186, 7 figs., *e*)

MACHINE PARTS (See also Machine-Shop Practise: Manufacture of "Globoidal" Type of Worm Gear)

"Compo" Porous Phosphor-Bronze Bearings

THIS describes a bearing produced as a die pressing by a patented process which leaves the structure of the material so porous that it absorbs oil in quantities up to 40 per cent of the volume of the material. Because of this, no oil grooves or lubricator holes are required.

It is said that the material will withstand pressures of 75,000 lb per sq in. and that its high oil content permits bearing loads much greater than those carried by ordinary bearing metals. When squeezed in a vise, it exudes oil from the pores. In some instances no additional lubrication is required. In other cases, however, a lubricator may be placed against the outside of the bush so that the oil finds a way through the bush. If, on occasion, there is a slight increase in temperature, oil is brought to the surface. Upon cooling, this lubricant is quickly absorbed again by the walls of the bearing. It is said that "compo" is not merely a compressed body of a mechanical mixture but a true alloy showing a distinct crystalline structure under a microscope. (*Automobile Engineer*, vol. 23, no. 310, September, 1933, p. 347, 2 figs., *d*)

MACHINE-SHOP PRACTISE

New Countersunk Riveting Process for Sheet Metal

ALTHOUGH primarily designed for riveted joints in aircraft construction, this process is said to be equally adaptable to the fabrication of sheet-metal products. It is said that the process introduced by De Bergue, Ltd., Manchester, has been successfully applied to the riveting of joints in the thinnest gages produced in modern stainless steel.

In operation, the rivet is placed through the hole in the sheets, and the original flat rivet head is brought into contact with the bottom riveting tool. The top riveting tool, which is specially shaped on its face, descends over the projecting shank of the rivet and with one quick squeeze causes the following simultaneous actions:

(1) The flat rivet head is forced flat into the two sheets, which sink together into a cup shape formed in the top tool, without distorting the sheets, which remain dead flat.

(2) A new cup head is formed on the rivet shank by means of a cupped depression in the top tool.

The finished rivet is in one solid mass, with the two sheets rested together. As the sheets are interlocked they cannot slide, the shear stress being consequently taken entirely away from the rivet shanks. In other words, the rivets merely serve to hold the two recesses together, while the recesses carry the shear stress, distributing them over considerable area. This results in a joint with lasting rigidity, and the unusual advantage of a riveted joint in thin sheet metal, having one side or surface perfectly flush, and possessing, it is claimed, approximately twice the strength of a standard joint with ordinary cup-head rivets. (*The Metal Industry*, vol. 43, no. 5, Aug. 4, 1933, p. 99, illustrated, *p*)

Manufacture of "Globoidal," Type of Worm Gear

ENVELOPING worm gears of the design known as the Hindley, hour glass," globoidal," or hollow type, have been well known, but no process for manufacturing them commercially has been available in the past. It is now said that one has been developed by the Michigan Tool Company, of Detroit, Mich., known as the "cone" worm. This latter is generated by means of one or more straight lines operating entirely in the axis of the worm and tangent to a circle formed by extending the sides of the worm wheel. The final generation is accomplished with the cutter and work piece positioned as the worm and worm wheel will later operate in service.

The cone wheel (Fig. 5) is generated with a hob having thread flanks of identical mating capacity with the worm, but of thinner cross-section; in other words, a worm having considerable backlash when mated with the wheel. The roughing operation is accomplished by advancing the centers of rotation toward each other. The thin hob leaves sufficient stock on the wheel blank to permit subsequent cutting. The final form is imparted by changing the relative rotative positions of the hob and work piece; that is, by the angular shift of either the hob or work piece about its axis. The normal rotation is advanced while finishing the flanks facing in one direction and by retracting it angularly while finishing the reverse flanks. The center distance and time relation are fixed during the finishing operation. Hence the true form is generated. See Fig. 6.

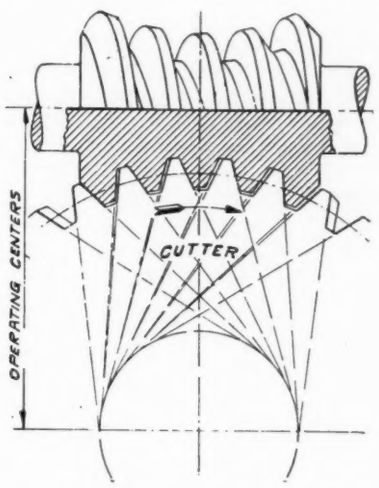

FIG. 5 GENERATING A "CONE" "GLOBOIDAL" WORM (WITH CUTTER REPRESENTING MID-PLANE OF WHEEL)

In the cone gear the worm flanks and wheel teeth, when cut by any plane passing through the worm axis, are both straight lines, tangent to a common circle, and hence contact simultaneously for the full depth of the thread and tooth. In the conventional worm gear the flank is of the involute form; whereas the worm thread is a straight line when intersected by a plane passing through the worm axis. Point contact necessarily results. The marked difference in instantaneous contact is accordingly explained. This is illustrated by a diagram in the original articles.

It is claimed that the cone worm provides a worm structure which follows the true curvature of the wheel which permits generation of a worm having a constant circular pitch corresponding exactly with the constant circular pitch of the worm wheel, whereas the conventional or straight worm has a con-

stant linear pitch that mates with a wheel having a constant circular pitch. Other characteristics of this type of gear are presented in the original article.

It is claimed, among other things, that the cone worm gear gives thirty times as much instantaneous contact as the parallel type and that an efficiency of 99.34 per cent was obtained with a cone worm gear; that cone gears successfully operated at 30,000 rpm. It is also claimed that the cone gear has superior ability to resist stripping resulting from the distribution of the load between more teeth than in conventional gears and the removal of the bending stresses on the teeth. In order to strip the teeth of a cone gear, it is necessary to shear them off at the root section, which is of quite generous proportions. (*Modern Machine Shop*, vol. 6, no. 5, October, 1933, pp. 26, 28, 30, and 32, illustrated, *d*)

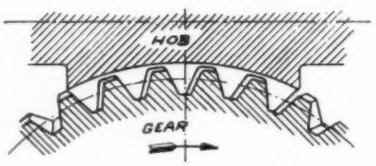

FIG. 6 GENERATING WHEEL WITH THIN-TOOTH HUB ON OPERATING CENTERS

MARINE ENGINEERING (See also Internal-Combustion Engineering: Sirron Pressure-Charged Diesel Engine; Monovalve Marine Diesel Engine)

Marketing and Distribution in Shipbuilding and Marine Engineering

THE author, A. C. Hardy, published in 1931 a paper discussing "Marine Engineering as a Marketing Proposition" under conditions which then existed. The present paper brings the subject up to date. The two years which have elapsed since the presentation of the first paper have shown that by producing better and more economical types, shipbuilders are forcing obsolescence on a great deal of existing tonnage. The rate of obsolescence of the existing tonnage is likely to be speeded up still more in the future.

The economy ships which have speeded up obsolescence have done so because of their low fuel consumption for very much greater speed than was possible a few years ago, together with increase in the rapidity and efficiency with which cargo can be handled in ports. This has increased the competitive spirit among shipowners and has enlarged the field for auxiliary manufacturers. It will also result, in the future, in carrying the world's goods in a smaller number of faster vessels, steam or Diesel, of very high efficiency.

The number of ships per given route must inevitably diminish in the future and world shipbuilding will decrease in quantity while improving in quality. From the point of view of the shipbuilder, a dangerous situation exists. Lack of work to a shipyard means first the discharge of skilled workmen and then the dismissal of the technical staffs, not easy to replace when necessary. This, in general, is the position today in those countries where shipyards are not assisted by governmental or other subsidies. Neither should shipbuilders close their yards to cut their losses. The slump is passing, and post-slump shipyards will be not only fewer but keener and better. They will go out for business rather than wait for business to come to them. Contracts in the future will be placed probably on an international basis, and already, for example, there are signs that Holland is actively allying itself with Scandinavia in this connection. This is already happening in England. There is a yard on the Tyne with excellent Canadian, French, and Scandinavian connections. There is a yard on the Clyde which has built simultaneously for South Africa, for India, and for Wallasey. The shipyards of Belfast have built for Dutch, for French, for British, and for American owners. No shipyard can prosper, however, unless it keeps rigidly abreast of modern requirements.

The mean speed of ships in the future will be higher, such as 12½ knots or more, and the extra speed will be attained on a relatively much lower fuel consumption. This is due to the use of internal-combustion engines and redesign of the ship itself, including propeller and rudder.

The "tramp" of the future is likely to be a vessel with a speed of 12 knots or over and of a size and type which in pre-slump days would have been dignified by the name of a cargo liner. She may have refrigeration space and accommodation for the carriage of vegetable oils and will operate in the trans-Pacific trade if necessary. The cargo liner may develop within the next few years into a ship with speeds of anything up to 18 knots in loaded condition. Electric propulsion is likely to be expanded.

The turbo-electric and Diesel-electric ships are discussed. The author claims that if British industries are to survive as separate self-supporting units, production must be studied and controlled and scientific marketing must be part of their program. The continued production of more and more efficient "models" would appear to be the keystone for the development of new construction other than that of a purely replacement nature. (A. C. Hardy, paper before the Institute of Marine Engineers, vol. 45, pt. 8, session 1933, 4 pp., abstracted from advance copy, *g*)

Shipbuilding Costs in Great Britain and Japan

IT WAS found difficult to obtain complete information regarding British shipbuilding costs, such data being generally regarded as trade secrets. The Japanese shipbuilders placed all the necessary information at the disposal of a committee appointed some time ago by the Society of Naval Architects of Japan to investigate Japanese shipbuilding costs in comparison with those of Great Britain under the normal exchange rate in gold currency. The comparison is limited to the building costs of passenger ships and does not take into account cargo-carrying vessels. Investigation confirmed that the costs of Japanese-built passenger motorships were somewhat higher than those of British-built vessels—mainly due to the lower aggregate efficiency of the general operative and administrative system in Japan.

The recent unfettered competition among Japanese shipbuilders has been excessive and it is possible that this will endanger the economic stability of the competing companies, the firms with the smaller capital in particular being likely to be forced out of business. The shortage of natural resources in Japan has hindered her advance in world competition, but this may now have changed because of developments in Manchukuo. (Y. Taji in *The Shipbuilder and Marine Engine Builder*, vol. 40, no. 283, October, 1933, pp. 437–439, *c*)

MEASURING INSTRUMENTS

High-Speed Engine Pressure Indicators

THE object of this study was to investigate the available types of indicators and to determine their limitations for various kinds of aircraft-engine research. The indicators considered included the Midgeley optical indicator, the Maeder microindicator, the R.A.E. or Farnboro electric indicator, and the Bureau of Standards indicator. In addition three telemeter

electric pressure units and a DeJuhasz indicator with all accessories were procured and tested. The Midgeley and Maeder indicators were not tested, since examination disclosed many of the shortcomings of these instruments. Certain changes were made in the DeJuhasz indicator in the course of the tests.

From the tests so far conducted, it appears that the sampling or averaging type of indicator, and the electric or instantaneous type, each has a field of usefulness not covered by the other. For transient and qualitative work, such as combustion study, the electric indicator will still provide the most satisfactory device, while for engine development, valve-timing studies, supercharging, etc., the sample device is probably the most useful. One type is strictly a laboratory instrument, while the other is a most convenient tool for the use of the engine research man, comparing in usefulness to the steam-engine indicator, as related to steam-engine development. (Ford L. Prescott, Air Corps, Wright Field, Dayton, Ohio. Air Corps Information Circular, vol. 7, no. 681, May 15, 1933, 6 pp. of text and 11 pp. of illustrations, *eA*)

POWER-PLANT ENGINEERING

Review of Recent European Boiler Designs

THE author describes the Brown-Boveri steam generator, the Vorkauf rotating boiler with turbine drive (MECHANICAL ENGINEERING, vol. 54, no. 12, December, 1932, pp. 869–871), the Zoelly high-capacity steam generator (MECHANICAL ENGINEERING, vol. 55, no. 1, January, 1933, pp. 50–52), and the Sulzer single-tube high-pressure steam generator.

In addition, mention is made of the British patent recently issued to Krupp in which various control means are provided in a once-through-flow type of boiler to meet the difficulties encountered in operation. To stop the salts and hardness-forming constituents from passing into the vapor in the form of a dust, which may deposit on the tubes or be conveyed to the engines by the steam, an excess amount of water, above that to be evaporated, is pumped through the boiler. On an average, the excess is about 10 per cent. The excess water retains the dust in solution and is separated from the steam in a specially designed separator. It is finally wasted in a concentrated state through heat exchangers. The amount of excess must be such that the limit of solubility of the substances dissolved in the feedwater is not exceeded during vaporization so that these substances are retained in the water. Where the feedwater is high in bicarbonates or similar substances which separate prior to vaporization, the solubility is increased by addition of acid. Because of the impossibility of maintaining a definite alkalinity with such treatment, an apparatus is provided for the separation of the gases from the feedwater so as to weaken the oxygen attack on the tubes. This excess water, taken off ahead of the superheater, also overcomes the difficulty of varying steam temperatures due to more or less water surging into the superheater and overcomes the coincident shock-like vaporization.

To accomplish all of this, auxiliary control means are required to insure accurately the desired ratio of excess water to total feedwater, supplemented by manual control for different loads. The feedwater flow is controlled by automatic means involving a combination of rate of steam flow and rate of excess water flow within the steam separator, and is supplemented by manual control. Other control means are necessary to synchronize the fuel supply with the feedwater flow and steam temperature.

The Krupp steam generators of the once-through-flow type disclosed, as well as some recent Sulzer patents, use several tubes in parallel for the water and steam flow. Under variable load conditions, either the amount of excess water is varied, as in Krupp's design, or the tubes are connected in parallel, series-parallel, or series to maintain a desirable velocity of flow therethrough. (*Combustion*, vol. 5, no. 3, September, 1933, pp. 20–24, 5 figs., *d*)

Apparatus for Cleaning Heating Surfaces on Both Sides

THIS development has been brought about in England by the Bayer Soot Blower Co., Ltd., and Flexotube, Ltd. The latter has developed a type of surface-scaling machine, designed for the express purpose of dealing with scale accumulations on the major heating surfaces of Lancashire boilers. One of the most interesting features is the method of coupling the drive to the motor armature shaft. In the Flexotube device, the flexible shaft is coupled directly to the armature shaft by means of a long hardened and ground steel spindle with a muff coupling, the spindle and coupling comprising a single fitting. The casing is fitted at this end with roller bearings which permit the casing to be freely floating on the shaft coupling spindle and when the unit is running at high speed in coiled positions of various radii, the roller bearing is sliding freely to and fro on the coupling spindle. This sliding movement, in addition to compensating for various degrees of flexibility between the shaft and the casing, also compensates for any stretch in the casing that might appear after the unit has been in service for some time. The scaling head itself is built of a series of aluminum-silicon alloy disks. The forward disk is recessed and equipped with 24 or 32 crucible-steel cutter wheels, each in sets of three or four. Each set of wheels is mounted on a high-carbon ("silver") steel spindle and left free to revolve on these axes. The alloy disks are, in turn, directly mounted on a specially made flexible coupling which has the effect of giving flexibility to the head and allows it to conform to radial surfaces and to absorb vibration. The machine is designed to run at speeds of 3000 to 3500 rpm. It is said that the machine leaves the chip marks on the surface, and if a highly finished surface is desirable, the head can be detached from its hand piece and a specially constructed steel-wire brush substituted.

As regards the external or combustion side, it is said that a soot and carbon deposit of a thickness of $^1/_{32}$ in. has the same heat-insulating property as asbestos $^5/_{32}$ in. thickness. The removal of the deposit becomes, therefore, very important. The system of removing it, as utilized in the Bayer soot blower, is based on a rotary steam-jet principle, the equipment comprising a series of five special blower units. One blower element is provided for each of the furnaces or fire flues fitted to the bottom of the flue tube, and carried in special brackets fitted by means of studs to the flue-tube bottom.

The element is fitted with a special operating head located outside the lower part of the ashpit and whereby steam is admitted and the blower rotated through an arc of approximately 300 deg by means of a handwheel. The rotation of these elements thoroughly cleans the flue tubes and plates, propelling the ash and soot deposits into the lower flue.

Another blower unit is fitted in the lower flue about 12 in. from base level, and revolved through an arc of approximately 300 deg by means of a T-handled key through the firing floor plate. This unit has the effect of thoroughly cleaning the under side of the boiler shell, the flue walls and floor, and propels the deposits into the side flues.

A blower unit is fitted to each side flue and these revolve through an arc of 180 deg from top to bottom, thoroughly cleaning the sides of the boiler, and the top and bottom of the flue, then propelling the soot and ash deposits into the main flue.

The five blowers are operated in sequence, and the soot and ash are carried forward in suspension by the action of the jets and draft, and finally discharged into the main flue, and thence to the chimney.

The whole system is suitable for boilers with steam pressure up to 200 lb per sq in., either superheated or saturated.

The Bayer company makes also a gun-type blower employing a balanced piston ported sleeve with spring-loaded packing liner and a simple method of inserting, withdrawing, and rotating the nozzle, which is arranged for either a handwheel or hand-chain control from the firing level.

Steam is automatically admitted and cut off by the action of the piston sleeve, while the nozzle is constructed of a special high-temperature metal. (*The Steam Engineer*, vol. 3, no. 1, October, 1933, pp. 19–21, illustrated, *d*)

TESTING

Alternating Hydraulic Pressure Tests of Welded Containers

THE fact that boiler parts respond differently to alternating stresses than they do to static stresses has been recognized for a long time. Recently, M. Ulrich, of Stuttgart, commissioned by the Association of Owners of Large Boilers, carried out a series of tests on the ability of welded joints to withstand alternating stresses, these tests being in part on bars submitted to alternating tension and in part on containers subjected to alternating hydraulic pressure stresses.

The alternating tension tests on welded and unwelded bars have shown that the shape of the bar and the character of the surface have a material effect on the resistance of the bar to alternating stresses.

In order, therefore, that conclusions from tests on bars could be applied to the presumed behavior of structural parts, it is necessary to make the bars substantially in the same manner as the parts for which they are to serve as guides. Fig. 7 shows the Wöhler lines for bars welded, unwelded, and reinforced by bands. Here *a* represents unwelded bars; *b*, welded bars with the ridge edges ground away; *c*, welded and ridges ground smooth; *d*, welded, ridges left undisturbed; *e*, welded and reinforced by bands.

From these curves, the influence of the shape and method of preparation of the pieces on their behavior is clearly seen.

Ulrich developed special testing apparatus for determining the ability of welded joints in welded containers to withstand alternating stresses. High-pressure water is supplied by a high-pressure, triple-acting pump, running all the time. From the main valve of the high-pressure piping, a branch leads to the container being tested, while another branch acts as an outflow and leads to an air pressure vessel. The main valve is alternately shifted in its action, delivering first into the pipe leading to the container under test and next to the air pressure container, this being done by means of a control manometer connected with the vessel under test and equipped with respect to a predetermined maximum and minimum pressure in the container under test. The valve is operated by this control manometer through an oil-pressure servomotor device. In this way, the desired alternations of pressure in the container are generated, while a safety valve in the pressure pipe leading to the container tested is provided to prevent the maximum pressure in the container from being exceeded. For further safety, a second manometer is installed on the container under test so arranged that if the maximum pressure for which the manometer is set is exceeded, the pump stops. In order to reduce the duration of the test and hence the cost thereof, the test conditions have been so selected that fracture should occur after 500,000 changes of load. The results of tests on two containers tested show that the data obtained from alternating tension tests apply to complete containers as well, even though in the present instance the welded joints, because of the greater difficulty of welding, do not stand the expected number of alternation of stresses. The tests by alternating water pressure on containers have further shown that the shape of the welded joints should be considered by the designer with utmost care and that when an attempt is made to compare the qualities of welded as compared with seamless containers, data that can be furnished by alternating-stress tests should not be left out of consideration. (Paper before the 23rd Annual Meeting of the Association of Owners of Large Boilers, in Munich, presented May 24, 1933, and published in a separate issue of the Proceedings of the Association, no. 42, July 15, 1933, abstracted through *Zeitschrift des Vereines deutscher Ingenieure*, vol. 77, no. 32, Aug. 12, 1933, p. 869, *e*)

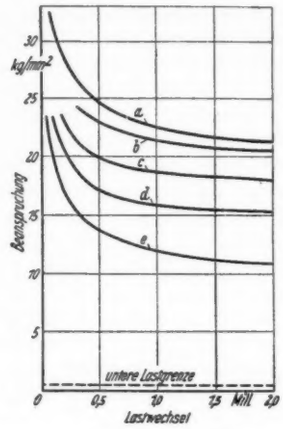

FIG. 7 WÖHLER LINES OF UNWELDED, WELDED, AND REINFORCED TEST BARS

(*Untere lastgrenze* = lower level of load; *Lastwechsel* = changes of load, in decimal fractions, the Germans use a comma instead of a period; *Beanspruchung* = stress.)

Motion Study

(*Continued from page 731*)

And this becomes the usual procedure in almost every plant where such a course of training has been started. After a few layouts, new tools, or new pieces of equipment have been installed without full consideration of these principles, the operating organization criticizes the resulting installation so severely that in the future the application of motion-economy principles becomes a regular part of such plant activity.

The next step is the use of this same approach on the part of the designer and manufacturer of the equipment when he is an outside supplier. More and more the users of equipment who are daily applying principles of motion economy will look for these points in the equipment they purchase; and if they cannot find them, I feel that they will build their own equipment.

We all know the influence of proper tools upon output and the reduction of manufacturing costs. And yet, when we see how little attention has been given to the development of tools and equipment from the viewpoint of motion economy, we cannot help but feel that here lies one of the greatest opportunities for development.

Men who can apply these principles will be in demand. And if the present designers and engineers do not meet these demands, others who do not yet know that "it cannot be done" will take their places.

SYNOPSES OF A.S.M.E. PAPERS

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MATERIALS HANDLING

Progress in Materials Handling. This report, well illustrated with views of new types of handling devices, deals with progress in the field of materials handling during 1932. Mentioning the savings possible by improved handling, the use of the material-handling formula, and sales problems in the field, the report is then devoted to sections in conveyors, speed reducers and drives, tramrail equipment, bulk handling, power-driven trucks and tractors, hand lift trucks, and tires and casters for trucks. (Paper No. MH-55-1.)

Rustless-Steel Conveyers—Their Availability, Application, and Use. The paper covers corrosion-resistant metals for material-handling use, giving tables of relative corrosion resistance and costs under reasonably average conditions, particularly where food products are concerned. The various available materials are briefly described, and their good and bad features and qualities are developed. The types of conveyers for which these materials have been used are given and the important and characteristic installation features of each are discussed. (Paper No. MH-55-2, by N. W. Elmer.)

Application and Design of the Floating Drive for Conveyers. Increasing demand for longer conveyers and conveyers more heavily loaded per foot of length has brought about the necessity of using multiple drives on a single strand of conveyor chain in order to keep the weight and cost of chain and carrier units down to a reasonable point. To meet this requirement there has been developed a floating type of driving mechanism so arranged that two or more drives located at considerable distances from each other will automatically synchronize as to speed so as to maintain proper driving action at each drive point. The paper describes in detail the development of this design and its application to various types of conveyers, pointing out the advantages obtained through its use not only as a synchronizing means, but also in properly distributing the total load, in effecting smoother operation, in replacement of the standard form of shear pin, etc. (Paper No. MH-55-3, by N. H. Preble.)

MANAGEMENT

Progress in Management. Management learned many profitable lessons from restricted conditions. The administration of business in times of failing business has brought into practise new methods of organization and of cooperation. The report covers developments in the marketing field, stabilization of employment, accounting and finance, plant layout, equipment, manufacturing processes, maintenance, production control, material control, safety, job standardization, wage rates and incentives, industrial relations, education, and research. (Paper No. MAN-55-1.)

Ten Years' Progress in Management, 1923–1932. Industrial management has undergone a severe test in the decade 1923–1932 due to violent fluctuations in industrial activity and sharp contrasts in the results of operating performance. Despite these changes it has made steady progress. It has been extended to all human activities where work is done. It has contributed to the accelerated rate of industrial development of the first six years, and its principles and practises have withstood the decisive trial of the deep depression of the last three. As an outcome of its application, well-managed concerns have passed through this period of business recession better than all others; as a result of its progress, management is now firmly established as a function in industrial operation. An examination of the changes in trends of some 25 industrial-management developments supports this major finding. (Paper No. MAN-55-2, by Leon P. Alford.)

Dissolving of Concentrated Industries. Far-reaching changes in the pattern of industrial organization are discernible from the small changes that are now taking place in the evolutionary process of American industry. These changes, just discernible in some instances, seem to indicate the trend toward a better balance between urban and rural population, the development of new raw materials for industry and new sources for existing materials from agriculture, the location of industrial plants in agricultural communities to permit of lower costs and greater economic security for the workers, the greater use of branch plants and branch assembly plants to afford access to and to better serve the domestic market, a limitation of the concentration of industrial units in the large cities, and the dissolving of some of these concentrated units by scientific relocation to more suitable places. As the process goes on it should result in a better total economic balance, greater economic security to all, and more wholesome enjoyment of life by all. In bringing about and furthering these changes, the engineer, guided by economic and scientific facts, principles, and laws, will be an important factor and will play a leading part. More and more, and more than ever before, the engineer must become economic minded if he is to play his part well and serve society as it should be served. (Paper No. MAN-55-3, by Harold V. Coes.)

Planning and Scheduling. The process of planning presupposes an aim to be attained, and therefore it is a purposeful action. It may or may not have a clearly conceived means for this achievement or a clearly determined order of procedure. These two elements, the means or facilities for the achievement of the aim and the order of their utilization, determine the quality of planning. The author analyzes the requirements, cites the work of Taylor and of Gantt, lists the preferred methods in use, and reaches definite conclusions, summing up with: Planning is a reversible process tending to reduce the element of random. (Paper No. MAN-55-4, by Walter N. Polakov.)

Management Policies and Practice in a Continuous-Production Gray-Iron Foundry. In a continuous-production gray-iron foundry with a capacity of 250 tons daily, chiefly making small castings, the management policies and practise have been directed toward obtaining maximum results by the continuous molding-pouring method with the minimum expenditure of time and effort. The operation of this continuous foundry is described in detail, through all the processes from handling the raw materials to the final inspection of the product. (Paper No. MAN-55-5, by W. G. Reichert.)

Fundamentals of Training. Fundamental principles involved in a modern training program are outlined. Beginning with an accepted definition of training, certain postulates are set up: (1) The careful selection of the learner. (2) The careful selection of the instructor. (3) The development of a suitable system of grading. (4) The analysis of the business for its training content. (5) The objectives of the training program. In selecting the candidate for training, attention must be focused on (*a*) physical, (*b*) manual, (*c*) mental, and (*d*) moral qualifications. A certain minimum of each capacity should be evident. The instructor must be a craftsman, a teacher, a psychologist. He must be a leader, an adviser, and a friend. A method of grading somewhat out of the ordinary is developed from Richard's formula for effective training. This system uses the performance of the average worker as a standard, rather than that of an imaginary ideal worker who has never existed. The instructor should analyze the business thoroughly for its instructional content, regrouping the units according

to the learning difficulty from simple to complex. This analysis may often be turned to useful account by the thoughtful executive in comparing the worth of various employees, reviewing the processes of the business, etc. The paper is concluded with the reminder that the perpetuation of a business depends upon the continual absorption of new blood, which gives to the study of training an unusual significance. (Paper No. MAN-55-6, by G. Guy Via.)

Applications of the Kmh Method of Analyzing Manufacturing Operation. The kmh method of analyzing industrial operation, first presented by the authors in a paper before the A.S.M.E. in 1928, is used to show variations in size of plants, in length of work periods, and in kmh rates of productivity, value of product, wages, and salaries for four industries in 1929. The trends of kmh operating rates from 1923 to 1931 for 110 concerns are also studied. Important findings are: High wages and high expenditures for supervision accompany high operating performances; the kmh factor is the most convenient unit for measuring plant capacity and a more satisfactory unit for measuring employment and unemployment than a census of workers; the optimum size of plant for most effective production is small; the optimum range of length of work period is considerably shorter than the longest periods that have prevailed currently; changes in productivity are substantially independent of the business cycle; and, due to continuously increasing productivity, the same quantity of product turned out by 50 concerns in a 51-hour week in 1923, could have been produced in a 35-hour week in 1931. (Paper No. MAN-55-7, by L. P. Alford and J. E. Hannum.)

OIL AND GAS POWER

Report on Oil-Engine Power Cost for 1931. This report, submitted by the Subcommittee on Oil-Engine Power Cost of the A.S.M.E. Oil and Gas Power Division, covers information on 119 oil-engine generating plants, with 330 engines, totaling 190,768 rated bhp. The survey is limited to the United States, and all data listed are for plants so located. The net output for the 119 plants represented amounts to 333,066,644 kwhr. Tables are given of lubricating-oil and fuel-oil economies of Diesel and semi-Diesel plants, and information on production cost, on comparative costs for three years, on lubricating oils and fuel oils, and on maintenance and operating labor, invested costs, etc. (Paper No. OGP-55-1.)

RAILROAD

Progress in Railroad Mechanical Engineering. This report briefly surveys the technical developments in 1932 in the field of railway mechanical engineering with specific reference to locomotives, rail cars, passenger cars, air conditioning, and special types of freight cars. (Paper No. RR-55-1.)

Horsepower and Tractive Effort of Steam Locomotives (Locomotive Ratios). Cole's Ratios, by the use of which the tractive-force curves of locomotives can be calculated and plotted, knowing certain of the locomotive dimensions, have been successfully used for the past 15 to 18 years. The Type E superheater, the feedwater heater, long-travel valve motions, and certain changes and refinements in proportion and design have tended to increase the power of steam locomotives built since 1920. The power calculated by Cole's method does not therefore accurately represent the actual power of modern steam locomotives. In his paper the author reviews the work of Cole and others, checking it against available test-plant and road-test data, and finds that some of Cole's constants still hold good in a great many cases. Others he finds it necessary to modify not only as to the figures, but also as to the method itself.

He develops constants for a new, easily applied method, based on boiler evaporation and a factor depending on the number of revolutions of the driving wheels, for use in connection with modern locomotives, and suggests the continued use of Cole's Ratios for locomotives in the design of which the modern factors are not included. (Paper No. RR-55-2, by A. I. Lipetz.)

Canadian Pacific Railway's Multi-Pressure Locomotive 8000. ***Its Steam-Generating System.*** The conventional type of locomotive boiler with stayed surfaces is generally considered as not suitable for pressures above approximately 300 lb per sq in. Therefore some sort of water-tube construction is essential for pressures materially higher. On the Canadian Pacific locomotive 8000 the Elesco multi-pressure system seems to adequately meet the high-pressure requirements, but offers corollary advantages contributing to ease of maintenance. The system consists of three units: first, the closed circuit; second, the high-pressure boiler; third, the low-pressure boiler. An outstanding feature of the water-tube construction is the use of distilled water in the closed circuit, so that no scale can be formed in the water tubes which are in contact with the fire. (Paper No. RR-55-3, by F. A. Schaff.)

Canadian Pacific Multi-Pressure Locomotive. ***Its Machinery, Locomotive Chassis, and Tender.*** The remarkable thermal efficiency of the multi-pressure locomotive of the German State Railways has commanded the attention of the entire railroad world. The introduction of this type of locomotive to American practise involves far more than the mere reproduction of the German machine, for the difference between the problems of availability, maintenance, and proportionate output on the two continents is profound. The author gives the reasons for the adoption of the type of engine selected to introduce the multi-pressure principle to American service, and describes the leading features of the construction of the chassis and cylinders. (Paper No. RR-55-4, by J. B. Ennis.)

Canadian Pacific Railway Multi-Pressure Locomotive 8000. ***Its Construction, Operation, and Maintenance.*** Higher steam pressures and temperatures have marked the progress toward greater power at reduced cost. Locomotive development has not kept pace with stationary practise in the use of higher pressures. After studying all available information on new types of locomotive and after investigating improved types of locomotive abroad, the Canadian Pacific Railway Company decided to construct a heavy freight locomotive for service on its severe mountain divisions. Its 2-10-4 multi-pressure locomotive 8000, which is described in the paper, was the result. (Paper No. RR-55-5, by H. B. Bowen.)

LIST OF ABSTRACTS OF A.S.M.E. CHICAGO MEETING PAPERS

THE following list contains the titles of papers presented at the Chicago Meeting, June 25–July 1, 1933, of the A.S.M.E., for which abstracts of approximately 1000 words and identical with those printed in the program are available. The list includes only papers that were not published in MECHANICAL ENGINEERING or that have not been ordered printed in the Transactions. Copies of these abstracts, as long as they last, may be had by addressing the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y. In ordering, please refer to the author, title, and key number in parentheses. A supplementary list contains the titles of some of these papers that were published in more complete form by the technical press, and indicates where they may be found. Synopses of the papers that have been ordered printed in Transactions will appear in MECHANICAL ENGINEERING as usual as soon as they are published.

C. WITOSZYNSKI, Wing Profiles With a Given Initial Moment (SA 13)
C. WIESELBERGER, The Influence of the Fuselage on the Wing (SA 14)
A. KLEMIN, Introduction to the Spin (SA 16)
A. VOLMERANGE, Rules for the Construction of Airplanes (SA 17)
HAROLD CAMINEZ, Aircraft-Engine Cooling Problem (SA 18)
FRED E. WEICK, Factors Regarding Propellers for Airships (SA 19)
JEROME LEDERER, Safety Maintenance Manual for Aeronautics (SA 20)
CHARLES H. DOLAN, Shock-Absorbing Panels for Instrument Mounting (SA 22)
L. H. BAUER, Air Sickness (SA 23)
JOHN E. YOUNGER, Design of Fittings for Metal Monocoque Structures (SA 24)
RICHARD C. GAZLEY, Aircraft Design as Influenced by Accidents (SA 27)
W. TRINKS and John H. HITCHCOCK, Roll-Neck Bearings (SA 31)
ROBERT F. VOGT, Stresses in Helical Springs (SA 33)
D. J. MCADAM, JR., and R. W. CLYNE, Influence of Corrosion Pits, Etc., on Fatigue (SA 34)
C. T. EDGERTON, Fatigue Tests of Helical Springs (SA 35)
D. H. YOUNG, Rational Design of Steel Columns (SA 38)
S. TIMOSHENKO, Stability of the Web of Plate Girders (SA 39)
J. P. DEN HARTOG, Amplitudes on Non-Harmonic Vibrations (SA 43)
O. FLACHSBART, Wind Pressure on Buildings (SA 44)
A. JAKKULA, The Theory of the Suspension Bridge (SA 45)
P. J. MURPHY, Compressed Air Plant for the Woodworking Shop (SA 49)
R. F. ONSRUD, Compressed Air in Woodworking Machinery (SA 50)

J. A. PAASCHE, Compressed-Air Equipment for Finishing (SA 51)
E. H. TENNEY, Standby and Reserve in a Pulverized-Fuel Plant (SA 53)
JAMES F. MUIR, Oil Firing in Pulverized-Coal Furnaces (SA 54)
H. F. JOHNSTONE, Removal of Sulphur Compounds From Waste Gases (SA 58)
R. M. HARDGROVE, Relation of Pulverizer Capacity, Power, Grindability (SA 60)
W. R. WOOLRICH and E. L. CARPENTER, Conditioning, Cooking, and Pressing Cottonseed (SA 63)
H. R. STRAIGHT, The De-Airing of Clays in the Ceramic Industry (SA 64)
E. A. WERT, S. SMITH, and E. T. COPE, Design Method for Flexible Piping Members (SA 66)
TOWNSEND TINKER, Surface Condenser Design and Operation (SA 68)
C. RICHARD SODERBERG, Moisture Problem in Steam Turbines (SA 72)
C. W. FOULK, Effect of Suspended Solids (SA 76)
W. C. SCHROEDER and C. H. FELLOWS, Determination of the Sulphate Ion in Boiler Waters (SA 77)
S. J. MEISENBERG and C. H. FELLOWS, Determination of Dissolved Oxygen in Feedwater (SA 78)
MALCOLM F. JUDKINS and WILLIAM C. UECKER, Cemented Carbide Cutting Tools (SA 80)
HERBERT R. ISENBERGER, Recent Progress in X-Ray Inspection of Welds (SA 81)
FRIEDRICH SCHWERD, Recent Investigations in Theory of Metal Cutting (SA 82)
OLIVER SMALLEY and W. WORLEY KERLIN, Development of Cast Iron for Machine Construction (SA 83)
H. H. WALTHER, Notes on Electric Cast-Iron Practice (SA 84)
ROBERT H. SPAHR, Education Within Industry in the Central States (SA 85)
JOHN T. FAIG, Training Apprentices in Times of Depression (SA 86)
A. F. MURRAY, Organizing for Manufacture of Diversified Product (SA 90)

CHICAGO PAPERS PUBLISHED BY THE TECHNICAL PRESS[1]

RICHARD C. GAZLEY, Aircraft Design as Influenced by Accidents. (*Western Flying*, June and August, 1933)
ROBERT F. VOGT, Stresses in Helical Springs (*Wire and Wire Products*, July, 1933)
C. T. EDGERTON, Fatigue Tests of Helical Springs (*Wire and Wire Products*, July, 1933)
J. P. DEN HARTOG, Amplitudes of Non-Harmonic Vibrations (*Journal of the Franklin Institute*, October, 1933)
E. H. TENNEY, Standby and Reserve in a Pulverized-Fuel Plant (*Combustion*, August, 1933)
JAMES F. MUIR, Oil Firing in Pulverized-Coal Furnaces (*Combustion*, June-July, 1933)
MARTIN FRISCH and G. C. HOLDER, "Grindability" and Actual Pulverizer Performance (*Combustion*, June-July, 1933. Also to appear in Fuels and Steam Power Transactions)
P. NICHOLLS and M. G. EILERS, Underfeed Combustion and Effect of Preheated Air (*Combustion*, June-July, 1933. Also to appear in Fuels and Steam Power Transactions)
ARTHUR C. STERN, Measurement and Properties of Cinders and Fly-Ash (*Combustion*, June-July, 1933. Also to appear in Fuels and Steam Power Transactions)
H. F. JOHNSTONE, Removal of Sulphur Compounds From Waste Gases (*Combustion*, August, 1933)
W. R. WOOLRICH and E. L. CARPENTER, Conditioning, Cooking, and Pressing Cottonseed (*Chemical and Metallurgical Engineering*, June, 1933, in abstract)
H. R. STRAIGHT, The De-Airing of Clays in the Ceramic Industry (*Chemical and Metallurgical Engineering*, August, 1933)
J. N. LANDIS, and S. A. TUCKER, Tests of Two 101,000-Sq-Ft Surface Condensers (*Power*, June, 1933. Also to appear in Fuels and Steam Power Transactions)
MALCOLM F. JUDKINS and WILLIAM C. UECKER, Cemented Carbide Cutting Tools (*American Machinist*, May 24, 1933, and June 7, 1933)
HERBERT R. ISENBURGER, Recent Progress in X-Ray Inspection of Welds (*Steel*, June 5, 1933)
OLIVER SMALLEY and W. WORLEY KERLIN, Development of Cast Iron for Machine Construction (*Iron Age*, Oct. 19, 1933)

[1] For copies of these papers, communicate directly with the publishers of the periodicals.

Power Test Codes

Radiation Pyrometers and Measurement of Surface Areas

AFTER a thorough study of the construction and use of the radiation pyrometers now available, the A.S.M.E. Power Test Codes Committee on Instruments and Apparatus has completed this chapter of the part of its code dealing with temperature measurement. Before this chapter is presented to the Committee on Power Test Codes and the Council of the A.S.M.E. for approval, these bodies are calling it to the attention of the public in general.

The committee in charge of this part of the Power Test Codes activity consists of C. F. Hirshfeld, chairman, W. A. Carter, secretary, C. M. Allen, E. G. Bailey, L. J. Briggs, C. R. Cary, J. D. Davis, R. E. Dillon, F. M. Farmer, J. B. Grumbein, W. H. Kenerson, E. S. Lee, E. L. Lindseth, O. Monnett, S. A. Moss, E. B. Ricketts, and W. A. Sloan.

This chapter on radiation pyrometers includes sections dealing with (1) the temperature range, (2) types of radiation pyrometers (total and selective), (3) description of specific instruments, (4) accuracy, (5) advantages and disadvantages as compared with the thermocouple and optical pyrometers, (6) installation and (7) calibration.

As is well known, radiation pyrometers utilize the heating effect of energy radiated from the hot body as an index of its temperature. They comprise three essential elements, namely, (*a*) an optical system designed to intercept a definite portion of the energy radiated from a portion of the surface of the body under test and to concentrate it upon a heat-sensitive element, (*b*) a heat-sensitive element, and (*c*) a measuring device. The usual heat-sensitive element is a thermocouple. With this element are employed the recording and indicating devices substantially the same as those used with thermocouple pyrometers. The chief advantage of the radiation pyrometer is that automatic records of temperature higher than those measurable with thermocouple pyrometers can be obtained with it.

Part 15 of "Instruments and Apparatus" on the Measurement of Surface Areas covers the polar and radial planimeters and is also available for critical comment.

By far the greater number of areas measured in engineering practise are plane figures. Some of these areas are regular forms and are tabulated in the handbooks while many more may be broken up into component parts which take the form of parallelograms or triangles, the areas of which may be readily calculated. The area of an irregular figure, especially one having a perimeter composed partly or wholly of curved lines, presents a more difficult problem. Methods have been advised for rapidly calculating the approximate area of such figures. Because of the increased knowledge of and confidence in mechanical integrating and averaging machines known as planimeters, the use of these methods has now been generally discontinued. The speed and accuracy attainable by the use of such instruments have been other factors which have relegated the older and slower methods of calculation.

Copies of the preliminary drafts of these two sections of "Instruments and Apparatus" are available to those specially interested. The committee will welcome suggestions for corrections and additions to these draft reports. Requests for copies of these drafts and comments on them should be addressed to C. F. Hirshfeld, care of the A.S.M.E., 29 West 39th Street, New York, N. Y.

CORRESPONDENCE

READERS are asked to make the fullest use of this department of "Mechanical Engineering." Contributions particularly welcomed at all times are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on its activities or policies in Research and Standardization.

Super Steam Plant for the Chicago Loop

To the Editor:

Construction may soon be started on a giant $8,000,000 steam plant to supply the entire central business district of Chicago. Most of the city's large office buildings, hotels, and department stores are located in this section and all have their own plants, but it is believed that the new ultra-modern central plant will be able to supply steam cheaper than it can be generated in the isolated plants.

The most important advantages of a central station over an isolated plant are: (1) smaller unit capital investment, (2) higher efficiency, (3) lower labor and maintenance costs. Since the section that this plant is to serve is already built in and since the prospective steam buyers have their own plants, the fixed charges of central station will be a heavy load in its competition with the isolated plants.

Of the three items of costs just mentioned, the first will be in favor of the isolated plants as the fixed charges will be zero. The other costs will be in favor of the proposed plant, but the question is, can the two combined offset the fixed charges of the new plant? It is not likely that the new plant will be able to operate at better than 85 per cent boiler efficiency, and we can assume 70 per cent for the efficiency of the isolated plants. This will give the new plant an advantage of 85/70 or 20 per cent on the cost of fuel. In regard to the labor and maintenance cost, it will not be able to do better than one-third that of the isolated plants. Fuel costs in Chicago are about 20 cents per million Btu, so that the fuel cost per 1000 lb of steam will be approximately 28 and 23 cents for the isolated and central plants, respectively. Since labor and maintenance costs are about one-third of the fuel cost, these will be 9 and 3 cents per 1000 lb of steam, respectively. For fixed charges we can assume 15 cents per 1000 lb of steam for the new plant, and, of course, zero for the isolated plants. So we have,

	Central plant	Isolated plant
Fuel cost, per 1000 of steam, dollars.....	0.23	0.28
Labor and maintenance, per 1000 lb of steam, dollars.....	0.03	0.09
Fixed charges, per 1000 lb of steam, dollars	0.15	..
Total cost, per 1000 lb of steam, dollars	0.43	0.37

On the basis of this analysis it does not seem that the undertaking is a sound business venture. But there is another side to it.

Figures of operating costs of Chicago buildings published by the National Association of Building Owners and Managers are much higher than the estimates in the above table. Fuel costs are given that run close to 50 cents per 1000 lb, but this can only indicate a very low degree of efficiency. The estimated costs for isolated plants given in the table above are not supposed to indicate what the actual costs are, but what can be obtained in a well-operated plant. And this would mean that what the proposed plant aims to accomplish, namely, reduced operating costs, could be achieved through the efficient operation of the existing plants.

N. T. Pef.[1]

Chicago, Ill.

Production and Purchasing Power

To the Editor:

The present moment is an extremely critical one in connection with the part engineers are to play in social reconstruction. They have proved that they can produce an affluence for all and there is little doubt that they, if given a free hand, could also distribute it. Distribution, no less than production, is an engineering process, if we focus our attention on need and available supply, rather than on proprietary rights and the rules of barter and exchange.

Hitherto we have allowed these latter completely to govern our social procedure, at least in peace time, and the result under the conditions of modern industry has been an indescribable mess. Four European countries have gone through revolutions and we here have run into a depression during which one-fourth of our population has become pauperized, and the major part of the remainder has come closer to that danger every day. There certainly is call for a new deal. The question is now: What position are engineers going to take in this new deal? Are they going to try to maintain the proprietary fictions which have brought us into our present "mess," or are they going to focus their attention on production and distribution as a physical process? If the former, they will contribute nothing that other social groups could not do as well. If the latter, they will introduce a new deal indeed, and one which hardly any other group could contribute.

I take my stand for the latter alternative.

This is admittedly a simplification of our social process, but one to which we, in my opinion, will inevitably have to come if we are to avail ourselves to the full of the possibilities offered us by modern technical development.

With this simplification in mind, it seems obvious that on the economic side we must concentrate on the question of purchasing power. In a well-arranged society there should be placed in the hands of everybody a purchasing power corresponding to what we consider his legitimate needs. These needs will vary with his function in society, and it is conceivable that we might wish to place in the hands of certain individuals quite extraordinary resources, because we feel that they would be able to use them for the social good more effectively and more intelligently than anybody else.

At the present time, however, there are moments when we cease to put into the hands of perfectly valuable members of

[1] Consulting Engineer. Jun. A.S.M.E.

society any purchasing power whatever. We do that, for instance, when suddenly it begins to dawn on us that we have vastly overexpanded our plant capacity—not in factories only, but in office buildings, hotels, amusement places, etc. We then take away all purchasing power from armies of carpenters, bricklayers, structural iron workers and others, with the consequence that the consumption goods intended for these people stay on the shelves and are not disposed of.

There is nothing unfamiliar in this and there is every indication that this was what happened in 1929. Thus, if we study the cost-of-living index for wage earners, we find that it varied as follows:

1925–26	1926–27	1927–28	1928–29	1929–30	1930–31
176.3	174.5	171.0	170.7	169.0	155.5

(The figures are those of the U. S. Bureau of Labor Statistics, weighted according to expenditures.)

In other words, from 1925–26 through 1929–1930 we find the supply steadily tending to outrun the purchasing power, as indicated by a steady drop in price level. In the summer of 1929 the *Annalist* index of wholesale prices shows a steep drop, indicating that the difficulty of disposing of goods became accentuated. The speculative frenzy continued a while longer, and it is possible that an overstraining of credit took place in this direction. There is, however, not a single indication of an overexpansion of credit outrunning the supply of goods. There is every indication of lacking purchasing power, becoming grave before the stock-market collapse. In other words, the collapse is preceded by price drops, not by inflations.

It would be extremely regrettable if engineers, instead of standing squarely for that matching of production with purchasing power without which they cannot do for the world what the state of their art would enable them to do, would allow themselves to be absorbed in a web of financial legerdemain, by which our social relations have hitherto been woefully obscured. This is said with full appreciation of the interesting and valuable discussion of credit inflation by Mr. R. E. Flanders in the October issue of MECHANICAL ENGINEERING and by Mr. C. E. Harwood elsewhere.

C. A. NORMAN.[1]

Columbus, Ohio.

BOOK REVIEWS AND LIBRARY NOTES

Introduction to Railway Mechanics

INTRODUCTION TO RAILWAY MECHANICS. By George V. Lomonossoff. Oxford University Press, New York, 1933. Cloth, $5^1/_2 \times 8^3/_8$ in., 179 pp., 92 figs., $3.75.

REVIEWED BY B. F. LANGER[1]

IN THIS book the author has collected a series of lectures delivered by him at the California Institute of Technology. He states in the preface that the "lectures were attended by engineers who wished to acquaint themselves with the scientific methods of solving railway problems, and by scientists wishing to find railway problems in the solution of which they could participate." It seems likely that the latter group obtained more pleasure and instruction from the lectures than did the former, since the book is written from an essentially academic point of view. The fundamentals of railway mechanics are stated in a very logical order and exact mathematical expressions are derived for even the simplest concepts.

The subjects covered are the equations of motion (useful displacements of the vehicle), the motion of the wheel and other parasitic motions, motion along curves, and railway economics. Added are brief descriptions of railway track and rolling stock. Many references are given to the literature on the subject.

For the railway engineer, the chapters on "Motion Along Curves" and "Traffic Control" are probably the most useful; the former particularly, since it gives a clear exposition of some fundamental principles that are known to too few American railway engineers. This chapter contains one misstatement, on page 94, where the author states that Uebelacker's method assumes that the position of the center of rotation of the wheelbase is known, and Heumann's method gives the first accurate way of determining it. Uebelacker's paper, published in 1903, does give a method of locating the center of rotation, and Heumann's method, advanced ten years later, is not more accurate but merely less laborious.

The book is intended as an introductory volume to a series, and as such it is very fine because it lays a solid mathematical foundation for the study of the more complicated problems which actually come up in practise. Taken by itself, it is too theoretical because it derives too many formulas which are not useful in themselves and are not used for the derivation of other, more useful, expressions.

[1] Research Laboratories, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Automotive Engines

AUTOMOTIVE ENGINES. By P. M. Heldt. Published by the author, Nyack, N. Y. Cloth, $5^1/_2 \times 8^1/_4$ in., 598 pp., illus., $6.

REVIEWED BY WILLIAM G. WALL[2]

THIS volume, like all of Mr. Heldt's articles and books, is interesting, and while there is very little originality in the treatment of the subject matter, he has furnished some very up-to-date information.

The first few chapters may appear rather juvenile, but are good for refreshing one's memory, and the book would hardly be complete without them.

It would be asking the impossible for a volume of this size to give complete information on any of the many subjects which it contains, but there are several chapters which come very near accomplishing this, among them being those devoted to pistons, piston rings and piston pins, and valves and valve gears. The principal omission that this reviewer finds is in regard to the author's rather brief treatment of the shape of the combustion head, which is, of course, a very deep subject, and the fact that because there is such a great difference of opinion in regard to its many details that it has got to be

[1] Professor of Machine Design, The Ohio State University. Mem. A.S.M.E.

[2] Consulting Engineer, Indianapolis, Ind. Mem. A.S.M.E.

such a controversial question, is probably one of the reasons for not having gone into it at greater length. Another criticism might be the brief information of the advantages and disadvantages of the different locations for the spark plugs. The reviewer has been particularly impressed, however, with the treatment of vibration and vibration dampers, which, by the simple explanations, is easy to understand, and at the same time, sufficiently complete.

The advance in automotive engineering is so rapid that it is difficult to have the last word in the progress of the art, and one is agreeably surprised to find in several instances that this has been done. Due to the author's lucid explanations, the book is pleasant to read, and should be an excellent one for the reference library of the engineer, as well as for the advanced student.

Books Received in the Library

AERONAUTICAL RESEARCH COMMITTEE, REPORT FOR THE YEAR 1932–1933. His Majesty's Stationery Office, London (British Library of Information, New York), 1933. Paper, 6 × 10 in., 94 pp., illus., 2s. Includes brief accounts of the work of the year upon aerodynamics, stability and control, spinning, structures, elasticity, fatigue, alloys, seaplanes, autogiros, engines, and aircraft noise.

AIR CONDITIONING. By J. A. Moyer and R. U. Fittz. McGraw-Hill Book Co., New York and London, 1933. Cloth, 6 × 9 in., 390 pp., illus., diagrams, charts, tables, $4. The first half of this book presents the theory of air cooling and discusses such matters as air filtering, cooling methods, refrigeration, humidity control, fans, etc. The second half considers the design of plants for office buildings, theaters, restaurants, factories, cars, and residences. Design requirements are considered and the necessary computations are given for various structures.

ALLOYS OF IRON AND SILICON. (Alloys of Iron Research, Monograph Series.) By E. S. Greiner, J. S. Marsh, and B. Stoughton. Published for Engineering Foundation by McGraw-Hill Book Co., New York, 1933. Cloth, 6 × 9 in., 457 pp., illus., diagrams, charts, tables, $4. Over twelve hundred articles were examined in compiling this summary of our knowledge of the iron-silicon alloys, and nearly five hundred of these were carefully studied in preparing it. The result is a concise but comprehensive critical summary of our knowledge of these alloys, in which their constitutions and properties are fully described. The metallurgist and engineer will find the book of great value. The monograph is the second issued by the Iron Alloys Committee of the Engineering Foundation.

ANCIENT OIL MILLS AND PRESSES. By A. G. Drachmann. Levin & Munksgaard, Copenhagen, 1932. Paper, 6 × 10 in., 181 pp., illus., diagrams, tables, 7.40 kr. A valuable contribution to the history of two early machines of great importance, the oil mill and oil press. The author discusses in detail the construction and working of these machines, basing his work upon examination of existing remains and early writers. There is a bibliography.

(1933) A.S.T.M. MANUAL ON PRESENTATION OF DATA WITH TABLE OF SQUARES AND SQUARE ROOTS, sponsored by Committee E-1 on Methods of Testing. American Society for Testing Materials, Philadelphia, 1933. Paper, 6 × 9 in., 45 pp., diagrams, charts, tables, $0.50. This pamphlet discusses the application of statistical methods to the problems of condensing the information in a set of observations and presenting the essential information in a concise, readily interpretable form. Various methods are examined critically and recommendations upon the presentation of data made. The report is the work of a committee of engineers who are at the same time expert statisticians.

A.S.T.M. STANDARDS ON ELECTRICAL INSULATING MATERIALS, prepared by Committee D-9 on Electrical Insulating Materials, September, 1933. American Society for Testing Materials, Philadelphia. Paper, 6 × 9 in., 242 pp., illus., diagrams, charts, tables, $1.25. All the specifications and test methods of the Society which relate to insulating materials are brought together in this volume. The report of the committee on the subject is also included, with its recommendations for changes.

A.S.T.M. STANDARDS ON PETROLEUM PRODUCTS AND LUBRICANTS, prepared by Committee D-2 on Petroleum Products and Lubricants, September, 1933. American Society for Testing Materials, Philadelphia. Paper, 6 × 9 in., 292 pp., illus., diagrams, charts, tables, $1.25. In addition to the fifty-two standards and tentative standards pertaining to petroleum which have been approved by the Society, this volume contains the 1933 report of the committee on petroleum products and lubricants. The report summarizes the changes in various standards recommended by the committee. A paper upon a procedure for measuring the bleeding of cup greases is also included.

A.S.T.M. STANDARDS ON TEXTILE MATERIALS. Prepared by Committee D-13 on Textile Materials. American Society for Testing Materials, Philadelphia, 1933. Paper, 6 × 9 in., 164 pp., illus., diagrams, tables, $1. The latest revisions of the specifications, methods of testing and definitions adopted by the Society are collected in this volume. A wide variety of mechanical fabrics is included; duck, tire cord, electrical tapes, yarns, sacking, tubular sleeving, and braids. There are also a psychrometric relative humidity table and photomicrographs of common textile fibers.

A.T.M.—Archiv für technisches Messen, Lieferungen 21–26, March, 1933–August, 1933. R. Oldenbourg, Berlin and Munich. Paper, 9 × 12 in., illus., diagrams, charts, tables, 1.50 rm. each. As in preceding instalments of this encyclopedia, present developments in technical measurement are discussed briefly by specialists. All fields of technology are included. The articles are punched for loose-leaf covers and classification symbols are provided, making it possible to interfile this material with preceding instalments in convenient form for reference.

ANHALTSZAHLEN FÜR DEN ENERGIEVERBRAUCH IN EISENHÜTTENWERKEN. (Wärmestelle Düsseldorf.) Edited by Verein deutscher Eisenhüttenleute. Third edition. Verlag Stahleisen, Düsseldorf, 1931. Cloth, 8 × 12 in., 119 pp., charts, diagrams, tables, 16 rm. A compilation of data relating to heat and power consumption in iron and steel works, calculated and compiled by the fuel station of the Verein deutscher Eisenhüttenleute. The data cover fuels, coke-oven operation, blast furnaces, open-earth, bessemer and electric steel works, melting furnaces, gas producers, mill furnaces, rolling mills, engines, etc. The figures are not intended as standard values. They are, however, typical of current practise and so of value in design and in comparing performances.

ATLAS METALLOGRAPHICUS. Lieferung 10, Tafel 73–80; Lieferung 11, Tafel 81–88. By Hanemann and Schrader. Gebrüder Borntraeger, Berlin, 1933. Paper, 8 × 11 in., illus., charts, tables, Lieferung 10, subscription price, 7.50 rm., single number, 15 rm.; Lieferung 11, subscription price, 6.75 rm.; single number, 13.50 rm. This atlas is designed to provide a complete collection of photomicrographs of metals for comparative purposes, taken from over 7500 specimens. The present parts are concerned with various iron alloys. One hundred and thirty-four photomicrographs are included, with the magnification, etching reagent, nature of the specimen and remarks on the structure shown. A brief explanatory text is also included.

AUTOMOTIVE CONSTRUCTION AND OPERATION. By J. C. Wright and F. C. Smith. Second edition. John Wiley & Sons, New York, 1933. Cloth, 6 × 9 in., 435 pp., illus., diagrams, tables, $3.50. A simple, practical textbook, intended for trade schools, garage mechanics, and automobile owners. The construction, functions, and repair of the various units of the automobile are explained in detail. The new edition has been thoroughly revised and modernized.

DAUERFESTIGKEIT VON SCHRAUBEN. (Mitteilungen der Materialprüfungsanstalt an der Technischen Hochschule Darmstadt, Heft 4.) By W. Staedel. V.D.I. Verlag, Berlin, 1933. Paper, 6 × 9 in., 102 pp., illus., diagrams, charts, tables, 8 rm. This treatise reports the results of an unusually thorough investigation of the fatigue resistance of commercial bolts. The influences of shape, material, and method of manufacture were determined by extensive laboratory tests. Rules are given for designing, manufacturing and assembling, and improper methods are pointed out.

DESIGNING FOR ARC WELDING. Second Lincoln Arc Welding Prize Competition Papers. Edited by A. F. Davis. Lincoln Electric Co., Cleveland, Ohio, 1933. Cloth, 6 × 9 in., 424 pp., illus., diagrams, charts, tables, $2.50. This volume contains nineteen of the papers submitted in the second Lincoln Arc Welding Prize Competition, including the winners of the six principal prizes. All deal with the use of arc welding in the design of machines or structures, and illustrate novel applications of the process. The papers included show applications to machinery, ships, buildings, bridges, large containers, pipes and pipe fittings.

EINGRIFFSGESETZE UND ANALYTISCHE BERECHNUNGSGRUNDLAGEN DES ZYLINDRISCHEN SCHNECKENTRIEBES. By W. Vogel. V.D.I. Buchhandlung, Berlin, 1933. Paper, 6 × 9 in., 62 pp., charts, diagrams, tables, 3.60 rm. A thorough analysis of the laws of worm gearing and of the principles of design. The theory is presented clearly, without the use of higher mathematics, and new processes of calculation developed. Graphical methods are used extensively.

ELEMENTS OF EUCLID, with an Introduction by Sir T. L. Heath. Edited by I. Todhunter. E. P. Dutton & Co., New York, 1933. Cloth, 4 × 7 in., 298 pp., diagrams, $0.70. Everyman's Library has added to its collection of the world's best books this reprint of Todhunter's edition of the "Elements" of Euclid. Sir Thomas Heath contributes a valuable introduction, which includes some useful bibliographic information. Certain omissions from the original edition have been added. The volume is inexpensive and of convenient size.

ELEMENTS OF HEAT-POWER ENGINEERING, Parts 2 and 3. By W. N. Barnard, F. O. Ellenwood, and C. F. Hirshfeld. Third edition. John Wiley & Sons, New York, 1933. Cloth, 6 × 9 in., 1200 pp., illus., diagrams, charts, tables. Part 2, $5.50; part 3, $4.50. These volumes complete this work which, in addition to its value as a textbook, is well suited for reference use. Volume two discusses steam-generating apparatus and prime movers, fuels, combustion and heat transmission; volume three, auxiliary equipment, the power-plant ensemble, air conditioning, and refrigeration. This extensive field is covered with sufficient thoroughness for most purposes, it is thought, and numerous references to sources of additional information are given.

ENERGETISCHE GRUNDLAGEN DER GASTECHNIK. (Coal, Coke, Tar, Vol. 30.) By F. Schuster. Halle (Saale), Wilhelm Knapp, 1933. Paper, 7 × 10 in., 254 pp., diagrams, tables, 17 rm. Chemists and engineers whose work includes the handling of gases as raw materials, intermediate or main products, will find this a very useful reference work. The author has collected the widely scattered data upon the behavior of gases when acted upon by heat, work, or electricity, and arranged them systematically. The result is a collection of physico-chemical formulas and numerical data of decided value.

HYDRAULICS. By H. W. King and C. O. Wisler. Third edition. John Wiley & Sons, New York, 1933. Cloth, 6 × 9 in., 292 pp. diagrams, charts, tables, $2.75. A presentation of the fundamental principles of hydraulics and their application in engineering practise, intended for beginning courses in the subject and also as a reference book. This edition has been thoroughly revised and partly rewritten. A discussion of the fundamental principles of fluid flow has been added, as well as a chapter upon non-uniform flow in open channels.

INDUSTRIAL RESEARCH LABORATORIES OF THE UNITED STATES, including consulting research laboratories. (National Research Council Bulletin No. 91, August, 1933.) Fifth edition, compiled by C. J. West and C. Hull. National Research Council, Washington, D. C., 1933. Paper, 7 × 10 in., 223 pp., $2. Over fifteen hundred laboratories maintained by industrial firms, trade associations, consulting engineers, and chemists are included in this useful directory, compiled as of January 1, 1933. The information includes the location, name of director, composition of staff, and field of work. A geographic index and an index of subjects are included.

INLAND TRANSPORTATION, Principles and Policies, a revision and extension of "Railway Transportation." By S. L. Miller. McGraw-Hill Book Co., New York and London, 1933. Cloth, 6 × 9 in., 822 pp., charts, maps, tables, $4. Professor Miller has thoroughly revised his well-known treatise upon railway transportation and extended it to include other forms of inland transportation by motor, airplane, waterway, and pipe line. The book is intended for those who wish to understand the existing transportation problem and the possibilities of the various "solutions" that have been proposed.

INTERNAL-COMBUSTION ENGINES, Theory, Analysis and Design. By R. L. Streeter and L. C. Lichty. Fourth edition. McGraw-Hill Book Co., New York and London, 1933. Cloth, 6 × 9 in., 539 pp., illus., diagrams, charts, tables, $4.50. This edition of this text is a complete revision attempting to tie together in a comparatively small treatise the theory, analysis, and design of internal-combustion engines. Nearly one hundred pages have been added to the work, and the latest data available have been drawn upon.

KOKEREI UND TEERPRODUKTE DER STEINKOHLE. (Monographien über chemisch-technische Fabrikationsmethoden, Band 13.) By A. Spilker, revised by O. Dittmer and O. Kruber. Wilhelm Knapp, Halle (Saale), 1933. Paper, 7 × 9 in., 198 pp., illus., diagrams, tables, 9.80 rm. Modern coking practise, especially German practice, is well covered by the new edition of this book, which takes account of recent changes in the industry. Coking practise, the utilization of by-products, and the distillation of tar are treated in a practical manner. The author is General Director of the Tar Utilization Company, at Duisberg.

JOHANN KUNCKEL (1630–1703). (Deutsches Museum Abhandlungen und Berichte, Fifth Year, Part 2.) By H. Maurach. Berlin, V.D.I. Verlag, 1933. Paper, 6 × 8 in., 64 pp., illus., tables, 90 rm. Kunckel's fame rests upon his place as the pioneer scientific glassmaker of Germany and his discovery of ruby glass. This brief biography gives the main facts of his life and work, paying especial attention to ruby glass, and to his literary masterpiece, the "Ars Vitraria Experimentalis," which for one hundred and fifty years remained the classic authority on glassmaking.

CHARLES PARSONS, HIS LIFE AND WORK. By R. Appleyard. Constable & Co., London, 1933. Cloth, 6 × 9 in., 334 pp., 15s. This biography gives an attractive picture of the great engineer, with a valuable account of his inventions and work. The development of the steam turbine and its application to ship propulsion are covered fully. The part played by Parsons in the optical-glass industry is explained. A chapter is given to his attempts to make diamonds, and another to his "auxetophone" for magnifying sound. Mr. Appleyard has written an interesting book of permanent value.

POWER SALES. By D. Taylor. McGraw-Hill Book Co., New York and London, 1933. Cloth, 5 × 8 in., 206 pp., tables, $2. This book, an outgrowth of articles in the *Electrical World*, is the first on the subject. It discusses a variety of problems met in extending central-station power service, and gives many suggestions for solving them. The author is sales supervisor of the Utility Management Corporation.

PROCEDURE HANDBOOK OF ARC WELDING DESIGN AND PRACTICE. By Lincoln Electric Co. Lincoln Electric Co., Cleveland, Ohio, 1933. Cloth, 6 × 9 in., 434 pp., illus., diagrams, tables, $1.50. Contents: Welding methods and equipment; technique of welding; procedures, speeds and costs for welding mild steel; weldability of metals; designing for arc-welded steel construction of machinery; designing for arc-welded structures; typical applications of arc welding in manufacturing, construction, and maintenance. The table of contents gives a good idea of the scope of this work, which aims to supply up-to-date practical information on design and procedure for arc welding. The text is clear and concise, and is supplemented by numerous drawings and photographs. Designers, as well as welders, will find the book helpful.

RAYLEIGH'S PRINCIPLE AND ITS APPLICATIONS TO ENGINEERING. By G. Temple and W. G. Bickley. Oxford University Press, London and New York, 1933. Cloth, 6 × 9 in., 156 pp., diagrams, charts, tables, $4.50. The purpose of this volume is to familiarize engineers with the utility of Rayleigh's energy method for the rapid, direct calculation of the approximate values of critical loads and speeds. The method is developed in such a way as to furnish both upper and lower estimates of the true value required, so that it enables critical loads and frequencies to be determined with close, known degrees of approximation.

REPORT OF THE FOOD INVESTIGATION BOARD FOR THE YEAR 1932. Great Britain, Department of Scientific and Industrial Research. His Majesty's Stationery Office, London (British Library of Information, New York), 1933. Paper, 6 × 10 in., 304 pp., illus., diagrams, charts, tables, 5s. The investigations carried out during the year at the various laboratories of the board are described. These include many studies of the effects of cold storage upon animal and vegetable foods, upon corrosion of cans and upon refrigeration upon shipboard. A section is devoted to researches by the Engineering Committee upon heat transfer, humidity measurements at temperatures below freezing, and other topics.

SCHREIBWERKZEUG UND SCHRIFTFORM (Deutsches Museum Abhandlungen und Berichte, Fifth Year, Part 4). By R. Blanckertz. Berlin, V.D.I. Verlag, 1933. Paper, 6 × 8 in., 142 pp., illus., 90 rm. A brief interesting history of the development of writing and writing instruments, with numerous illustrations.

WALLACE CLEMENT SABINE, a Study in Achievement. By W. D. Orcutt. Privately printed by the Plimpton Press, Norwood, Mass., 1933. Cloth, 6 × 10 in., 376 pp., illus., $5. Mr. Orcutt's book is not a formal biography. From the diaries of Sabine's mother, from contemporary accounts of his achievements and from the tributes of men

who knew him well, has been composed a living picture of the great scientist. His achievements in architectural acoustics, his ability as a teacher and administrator and his work during the World War are adequately treated, but still more prominent is the man himself, as an attractive, engaging human being.

SHIP DESIGN, RESISTANCE AND SCREW PROPULSION. Vol. 1. Design of Ship Forms and Their Resistance. By G. S. Baker. Journal of Commerce and Shipping Telegraph, Liverpool, 1933. Cloth, 7 × 10 in., 228 pp., charts, tables, 25s. In 1915, the author, the superintendent of the William Froude Laboratory, published his "Ship Form Resistance and Screw Propulsion," the first work based upon study of the performance of cargo vessels. The present work replaces that book and includes the results of the experimental investigations of the past eighteen years.

The first volume, "The Design of Ship Forms and Their Resistance," presents a valuable collection of data, largely derived from the author's own work, together with as much discussion of the theoretical side of the subject as is considered necessary to the practical designer. The book is an important addition to the literature of ship design.

STEAM AND GAS ENGINEERING. By T. E. Butterfield, B. H. Jennings, and A. W. Luce. Second edition. D. Van Nostrand Co., New York, 1933. Cloth, 6 × 9 in., 488 pp., illus., diagrams, charts, tables, $4.50. This is an introduction to the development of heat and power from fuels, which emphasizes steam equipment somewhat more than internal-combustion engines. The material is based on thermodynamics, the construction and operation of a variety of apparatus being used as a background. The new edition has been thoroughly revised, much new matter being substituted, and other parts rewritten and rearranged.

TWENTY-FIVE YEARS OF CHEMICAL ENGINEERING PROGRESS, 1908–1933, Silver Anniversary Volume, American Institute of Chemical Engineers. Edited by S. D. Kirkpatrick. D. Van Nostrand Co., New York, 1933. Cloth, 6 × 9 in., 373 pp., diagrams, charts, tables, $4. In commemoration of its twenty-five years of life, the American Institute of Chemical Engineers has published this interesting souvenir volume. Twenty-five essays by prominent specialists describe the advances during the last quarter-century in the principal industries served by the chemical engineer. The industries include the manufacture of chemicals, paper, sugar, soap, paints, plastics and glass, the processing of coal and refining of petroleum, fractional distillation, evaporation, water purification, etc.

VERTEILUNG DER HYDRAULISCHEN ENERGIE BEI EINEM LOTRECHTEN ABSTURZ. By H. Rouse. R. Oldenbourg, Munich and Berlin, 1933. Paper, 8 × 11 in., 38 pp., illus., diagrams, charts, tables, 3.60 rm. A theoretical and experimental investigation of the behavior of water when flowing in curved paths. A practical method of determining the pressure of any desired cross-section of a falling stream in an open channel is developed.

DIE WIRTSCHAFTLICHKEIT DER BRAUNKOHLENSTAUBFEUERUNGEN IN ABHÄNGIGKEIT VON DER MAHLFEINHEIT. (Coal, Coke, Tar, Vol. 29.) By H. Stimmel. Halle (Salle), Publisher, Wilhelm Knapp, 1932. Paper, 7 × 10 in., 56 pp., diagrams, charts, tables, 5.60 rm. Coarse grinding costs less than fine grinding, but the cost of drying the brown coal is greater in the former case. This volume presents the results of extended experiments undertaken to find the most economic degree of fineness. The tests were made upon a large scale and the results are carefully discussed from all aspects.

WHAT'S GOING ON

The John Fritz Gold Medal Awarded Posthumously to John Ripley Freeman

THE John Fritz Medal Board of Award has awarded its gold medal posthumously to John Ripley Freeman, past-president, The American Society of Mechanical Engineers. Mr. Freeman's sudden death on October 6, 1932, occurred while the board of award was engaged in the procedure of selecting him as medalist.

The citation reads: "Engineer—pre-eminent in the fields of hydraulics and water supply, fire insurance economics, and analysis of earthquake effects."

Mr. Freeman made noteworthy contributions to water power, water supply, and other branches of hydraulic engineering, to fire-preventive construction and protection of industrial buildings, and to the investigation of earthquakes from scientific, structural, and insurance points of view. A biographical note on Mr. Freeman's career appeared in the November, 1932, issue of MECHANICAL ENGINEERING.

The Board is composed of sixteen recent past-presidents of the four national engineering societies of Civil, Mining and Metallurgical, Mechanical, and Electrical Engineers.

Secretary Wallace to Address A.A.A.S.

SECTION M (Engineering) of the American Association for the Advancement of Science will meet in Boston, Mass., December 27, 1933, to January 2, 1934. On Friday, December 29, at 8:30 P.M., the Hon. Henry A. Wallace, Secretary of Agriculture, will deliver an address on the engineer and the farm problem, in the ballroom of the Statler Hotel. This will provide the keynote for a number of papers to be given at a joint session of Section M (Engineering) and Section O (Agriculture) on the following day.

Chemical Exposition, New York, Dec. 4 to 9

THE Fourteenth Exposition of Chemical Industries will be held at the Grand Central Palace, New York, N. Y., December 4 to 9. Exhibits will include raw materials; finished products, such as chemicals, dyes, solvents, plastics, lacquers, varnishes, enamels, and waterproofing and acid-resisting coatings; and machinery, equipment and instruments for plant and laboratory. Educational exhibits comprise the results of recent research.

Symposium on Wood Preservation Now Available

IN MARCH of this year a symposium of papers on wood preservation was arranged by the Wood Industries Division of the A.S.M.E. H. B. Carpenter, secretary of the Division, now announces that these papers with discussion will be available in pamphlet form on December 1 at seventy-five cents a copy and may be obtained by addressing the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y. The papers in the symposium are as follows:

"Introduction and Summary to Wood Preservation," by George M. Hunt, Forest Products Laboratory.

"Creosote and Creosote Mixtures," by R. S. Belcher, Atchison, Topeka & Santa Fe Railroad Company.

"Zinc Chloride," by L. C. Drefahl, Grasselli Chemical Company.

"Sodium Fluoride and Fluoride-Phenol Mixtures," by H. B. Bishop, Sterling Products Corporation.

"Fluoride-Phenols in Europe," by A. Rabanus.

"Zinc Meta-Arsenite," by L. P. Curtin, Curtin-Howe Corporation.

"Fire-Resistant Treatments," by E. F. Hartman, Protexol Corporation.

Actions Taken by A.S.M.E. Executive Committee

AT THE October 31 meeting of the Executive Committee of the A.S.M.E. Council the following actions of general interest were taken.

The personnel of the Committee on Junior Participation (see report of Executive Committee, MECHANICAL ENGINEERING, November, p. 711) as announced by President Potter, is as follows: R. F. Gagg, Chairman, Paterson, N. J.; J. H. Adkison, Tulsa, Okla.; S. F. Duncan, Los Angeles, Calif.; William J. Hargest, Brooklyn, N. Y.; Richard Kutzleb, Brooklyn, N. Y.; C. W. Messersmith, Lafayette, Ind.; John C. S. Moore, Chatham, Canada; and D. B. Westrom, Bloomfield, N. J. It is expected that the committee, whose work is already under way, will report at the Annual Meeting.

COORDINATION COMMITTEE

At the June 25 meeting of Council, the Committee on Local Sections presented a resolution asking President Potter to call together in conference other societies with a view to setting up one national organization of engineers. The resolution was referred to the A.S.M.E. representatives on the Coordination Committee of the United Engineering Trustees, which has been making an exhaustive study of this problem. W. L. Batt, chairman of this committee, reported that it was the opinion of those who had discussed this matter for the past year that the suggestion of the Committee on Local Sections was not timely. The Executive Committee of Council requested Mr. Batt and the A.S.M.E. representatives on the Coordination Committee to discuss this matter further at the December meeting of Council. It was also deemed advisable to present the entire matter of joint relations with engineering societies in an article in MECHANICAL ENGINEERING.

AMERICAN ENGINEERING COUNCIL

The financial affairs of the American Engineering Council, which had been the principal discussion at a meeting of its Administrative Board on October 27 and 28, were discussed by the Executive Committee. It was the opinion of those present that the American Engineering Council was carrying on worth-while work. The view was expressed that the function of the American Engineering Council should be discussed in MECHANICAL ENGINEERING.

The following A.S.M.E. delegation for 1934 on the American Engineering Council was nominated: Paul Doty, Chairman, L. P. Alford, Ralph E. Flanders, D. Robert Yarnall, and A. A. Potter.

E.C.P.D.

A report was received on the first annual meeting of the Engineers' Council for Professional Development (see MECHANICAL ENGINEERING, November, pp. 692–693 and 710). C. E. Davies was authorized to act as secretary for the E.C.P.D. The dates of the expiration of terms of the A.S.M.E. representatives on the E.C.P.D. were set as follows: John H. Lawrence, 1934; W. E. Wickenden, 1935; C. F. Hirshfeld, 1936.

CAPITAL GOODS

It was reported that four members of the Committee on Capital Goods Industries (see A.S.M.E. Executive Committee Report, MECHANICAL ENGINEERING, November, p. 711) had accepted, as follows: Ralph E. Flanders, L. P. Alford, W. W. Macon, and L. W. W. Morrow. Steps have been taken to prepare a platform for the work of the committee, industrial leaders are being sounded out as to the method of attack on the problem, studies are being made in Philadelphia at the suggestion of the committee, and other work is under way to secure the cooperation of the Public Works Administration in making funds available for the repair and improvement of public buildings. It is expected that a report will be available at the A.S.M.E. Annual Meeting.

SALARIES OF ENGINEERS

A communication from Alonzo J. Hammond, president, Am. Soc. C.E., requested that the A.S.M.E. cooperate in a study of local and regional salaries and earnings of engineers. The communication was referred to the A.S.M.E. representative, H. C. Meyer, Jr., on the Construction Industry Code Committee.

POLICIES AND BUDGET

H. R. Westcott presented an outline of the plan of procedure for the second part of the report of the Committee on Policies and Budget, which is too extensive to be presented at this time. For a brief summary of the first report, see the summary of the A.S.M.E. Council Meeting at Chicago, MECHANICAL ENGINEERING, August, pp. 481–483.

LOCAL SECTIONS

It was pointed out that the recommendation of the Committee on Local Sections resulting in the action of Council in June temporarily suspending fourteen Local Sections (see "Recommendations of Committee on Local Sections" MECHANICAL ENGINEERING, August, p. 482) was not in accord with the by-laws of the A.S.M.E., which require a 60-day notice to Local Sections about to be suspended. The Executive Committee, therefore, rescinded this action, and referred the matter back to the Committee on Local Sections for review.

AWARDS

The recommendation of the Committee on Awards that Junior Members be permitted to compete for the Junior Award only during the period allowed for Junior Membership, i.e., the first six years of such membership, was approved. Announcement of the names of the recipients of the awards for 1933 will be made at the A.S.M.E. Annual Meeting.

It was voted to endorse the petition to the Federal Administrator of Public Works for the erection of a new Naval Model Basin recommended by sixteen membes of the A.S.M.E. and officially requested by the Society of Naval Architects and Marine Engineers.

APPOINTMENTS

By the death of Past-President Charles Piez on October 2 the Council terms of W. L. Abbott and Charles M. Schwab were extended to 1934 and 1935, respectively. Dr. W. F. Durand returns to Council for the period until December, 1933.

The following appointments were announced:

To the Committee on Education and Training, Robert H. Spahr (4-year term expiring 1937)

To the Committee on Awards, H. Diederichs (unexpired term of D. S. Kimball, 1936)

To the Sectional Committee of Standardization Committee on Unification of Rules for the Dimensioning of Furnaces for Burning Solid Fuel, V. G. Leach and John VanBrunt

To the Advisory Council, Construction Industry, L. W. Wallace, alternate for Henry C. Meyer, Jr.

To represent the A.S.M.E. at the Fiftieth Anniversary of the Société Francaise des Eléctriciens, November 23–26, 1933, Chas. de Freminville

Honorary chairmen of A.S.M.E. Student Branches were appointed, as follows: Bucknell University, Lewisburg, Pa., Geo. M. Kunkel; Catholic University of America, Washington, D. C., Geo. A. Weschler; Colorado Agricultural College, Ft. Collins, Col., Jos. Pinsky; Lewis Institute of Technology, Chicago, Ill., J. S. Kozacka; University of North Dakota, Grand Forks, N. D., Alexis J. Diakoff; Pennsylvania State College, State College, Pa., Chas. L. Allen; Rutgers University, New Brunswick, N. J., Ubert C. Holland; Tulane University of Louisiana, New Orleans, La., Wm. B. Gregory; Worcester Polytechnic Institute, Worcester, Mass., B. Leighton Wellman.

National Bureau of Engineering Registration

THE National Bureau of Engineering Registration is operated as a function of the National Council of State Boards of Engineering Examiners, assisted by an Advisory Board of Representatives from seven national engineering societies. It was established primarily for the convenience of engineers, especially those practising in more than one State, to minimize the effort and expense of securing registration. The Bureau also constitutes a clearing house for the convenience of the registration authorities of the various States having laws regulating the practise of professional engineering and acts as a reliable source of verified information regarding the professional records of engineers.

The Certificates of Qualification issued by the Bureau are in no sense obligatory for the applicant nor binding upon the State Boards of Registration, nor does the Bureau assume any responsibility to the applicant for securing his legal registration authorizing the practise of engineering in any State. However, the Constitution of the National Council and the engineering registration laws of some states specifically provide for the acceptance of certificates issued by the National Bureau of Engineering Registration.

PERSONNEL AND REPRESENTATION

The Committee on National Bureau of Engineering Registration is as follows: Hugh A. Kelly, Chairman, Jersey City, N. J.; D. B. Steinman, New York, N. Y.; H. D. Mendenhall, Tallahassee, Fla.; P. H. Daggett, New Brunswick, N. J.; O. Laurgaard, Portland, Ore.; and T. Keith Legaré, Executive Secretary, Columbia, S. C.

The national engineering societies are cooperating with the National Council through an advisory board on which the following representatives have been appointed:

American Society of Civil Engineers, George T. Seabury

The American Society of Mechanical Engineers, John H. Lawrence

American Institute of Electrical Engineers, Walter I. Slichter

American Institute of Chemical Engineers, J. C. Olsen

Society for Promotion of Engineering Education, R. I. Rees

American Railway Engineering Association, R. E. Warden
American Association of Engineers, C. J. Ullrich.

REQUIREMENTS AND FEES

A Certificate of Qualification will be issued only to an applicant who fully complies with the minimum requirements for a professional engineer and who conforms with the other regulations of the Bureau, which may be obtained by communicating with the Executive Secretary.

The charges for services of the Registration Bureau are as follows:

The fee for investigating and verifying the professional record of an engineer is $10.00, which fee must accompany application and will be retained by the Registration Bureau regardless of whether or not the results of the investigation warrant the issuance of a Certificate of Qualification.

When an application for a Certificate of Qualification is approved, the applicant will be so notified by the Bureau and upon payment by him of an additional fee of $5.00 the Bureau will furnish the applicant with a photostatic copy of his verified record and also with a separate Certificate of Qualification suitable for framing.

Applications for Certificates of Qualification must be made on forms furnished by the Bureau and filed with the Executive Secretary, National Bureau of Engineering Registration, P. O. Drawer 1404, Columbia, S. C.

Twist Drill List of Sizes Simplified

STIMULATED largely by the principal users of drills, Technical Committee No. 7, of the Sectional Committee on the Standardization of Small Tools and Machine Tool Elements, has completed a proposed American Standard for the diameter and length of twist drills. This standard, which covers sizes from 0.0156 to 0.5000 inches diameter, is now before the S.A.E., N.M.T.B.A., and the A.S.M.E. for approval in their capacity as joint sponsors for this sectional committee.

This project was initiated in 1928 under the procedure of the American Standards Association. Following favorable action by the sponsor bodies, the standard will go to the A.S.A. for review and designation as an American Standard.

The list of proposed standard sizes provides at least three suitable tap drills for every American standard screw thread within its range, the three drills for each size giving corresponding depths of thread suitable for different classes of fit and kinds of metal. This single series of sizes is intended to replace four lists now in general use, namely, fractional sizes, wire-drill sizes, letter sizes, and metric sizes. The committee found that these four lists of drill sizes combined did not give a satisfactory increment of size, with a result that it was found necessary to introduce fifteen new sizes in order to make the increment consistent and suitable for meeting all the purposes noted. However, these new sizes should not be considered as additions to the list, as in every case but two, the new size replaces from one to three old sizes. The result, therefore, is an elimination of 160 sizes out of a previous 270, giving a 59 per cent reduction in number of sizes to be regularly stocked by drill manufacturers, dealers, and users.

It is understood that the drill manufacturers will continue to carry most of these sizes for their export trade, but the users have taken the position that the drill manufacturers' foreign requirements is no reason for handicapping American industry with an unnecessarily large list. Furthermore, there is the important advantage to the small user that the small-town dealer can now, without increasing his investment in stock, intelligently carry a complete list of sizes, which before was a commercial impossibility because of the infrequent calls for many of those previously listed.

Copies of the proposed standard may be obtained for purposes of comment by addressing a request to C. B. LePage, Assistant Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y.

Cast-Iron Soil Pipe and Fittings Standardized

ON October 27, 1933, two hundred copies of the proposed American Standard for Cast Iron Soil Pipe and Fittings were sent out to a carefully selected list of interested firms, individuals, and organizations for their review and criticism. After final revision, which will be based on the replies received from this distribution, the standard will be approved under the procedure of the American Standards Association and published for general use.

This proposal covers standard dimensions, tolerances, and weights for cast-iron soil pipe and for soil-pipe fittings in sizes 2 to 15 in. The list of fittings in sizes 2 to 6 in. includes 39 separate items among which are bends, branch fittings, and traps, each with its several necessary variations, as well as reducers, increasers, plugs, ferrules, etc. The list of fittings of larger size, 8 to 15 in., includes 19 items. As it now stands, this standard represents a decided simplification of the list of items at present manufactured; almost 40 per cent of these having been eliminated as either obsolete or inconsistent with good sanitary practise. The standard also includes specifications for marking, quality, testing, coating, threading, inspection, and a glossary on nomenclature.

The standardization of cast-iron soil pipe and fittings is one of eight subdivisions of the project assigned to the Sectional Committee on Standardization of Plumbing Equipment, sponsored jointly by the American Society of Sanitary Engineering and The American Society of Mechanical Engineers.

Copies of the proposed standard may be obtained for purposes of comment by addressing a request to C. B. LePage, Assistant Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y.

Candidates for Membership in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after December 26, 1933, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Members desiring further information, or having comments and objections, should write to the Secretary of the A.S.M.E. at once.

NEW APPLICATIONS

ADAMS, E. EUGENE, Chicago, Ill.
AITKEN, MURRAY, Seattle, Wash.
BARTA, GEO. L., JR., Brooklyn, N. Y.
BOOTH, DANIEL M., Mexico, D. F., Mex.
BRISCOE, CONWAY B., St. Louis, Mo.
CHAMBERS, WILLIAM H., JR., San Francisco, Calif.
CHISHOLM, C. R., Baltimore, Md.
CLOUSING, LAWRENCE A., Evanston, Ill.
COBURN, PHILIP J., Bronx, N. Y.
DiGENNARO, ANTHONY, Baltimore, Md.
DOLE, MYRON W., Belmont, Mass.
GASSMANN, JOHN A., Valley City, N. D.
GOLLADAY, H. D., Wisconsin Rapids, Wis.
HARDING, HOWARD V., Port Washington, L. I.
HURT, R. M., Colombia, South America
JENKINS, J. BEAUMONT, Roswell, N. M.
JOHNSON, Lloyd M., Chicago, Ill.
KITT, SAMUEL, Brooklyn, N. Y.
LARSON, DELMAR T., Denver, Colo.
LINDSEY, ROY, JR., Los Angeles, Calif.
MEEHAN, JAMES, Philadelphia, Pa.
MILES, C. B., Omaha, Nebr.
PAULY, W. C., Los Angeles, Calif.
PETERS, JOHN KURT, Omaha, Nebr.
POWER, J. A., Houston, Tex.
RHINELANDER, HARRY W., San Antonio, Tex.
RUGH, JOHN M., Providence, R. I.
RUSHO, ERNEST J., Blanchard, Idaho
SIDLER, PAUL R., New York, N. Y.
SPIEVAK, L. A., Atlanta, Ga.
STEVENSON, EDMUND R., Detroit, Mich. (Rt)
TUPLING, C. G., Portland, Ore.
TURNER, LEE, Wilkes-Barre, Pa.
URSCHALITZ, PAUL E., Detroit, Mich.
VANDERVEEN, FRANCIS A., London, England
WALTON, ARTHUR LEE, San Diego, Calif.
WARREN, W. D., Montreal, Quebec, Canada
WELLS, E. H., JR., New York, N. Y.
WOOD, HARRY C., Plainfield, N. J.

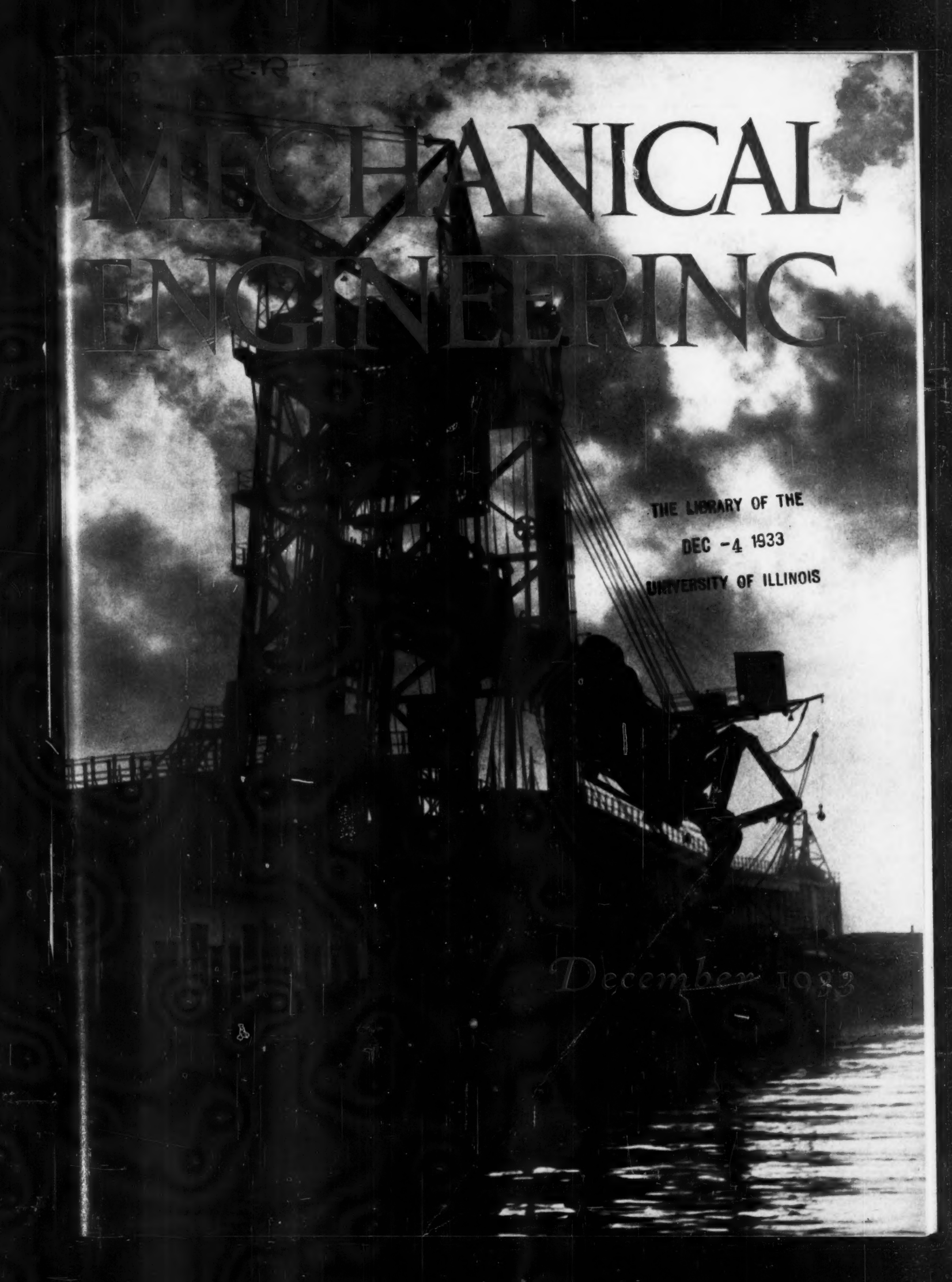
CHANGE OF GRADING

Transfers from Associate-Member

MOLLER, JOSEPH A., Chicago, Ill.
TUVE, G. L., Cleveland, Ohio

Transfers from Junior

ANANTRAM, R., Shahdara Mills, Nr. Lahore, India
deVARONA-AGUERO, P., Camaguey, Cuba
DONNELLY, LIEUT. JAMES B., New York, N. Y.
HEDDELL, DOUGLAS, Los Angeles, Calif.
HOGE, WALLACE W., New York, N. Y.
ISHAM, CLARENCE A., New York, N. Y.
MOODIE, T. EDWARD, Atlanta, Ga.
PEF, N. T., Chicago, Ill.
TRULSON, ARTHUR F., Ashland, Wis.
VEDDER, W. O., Hagerstown, Md.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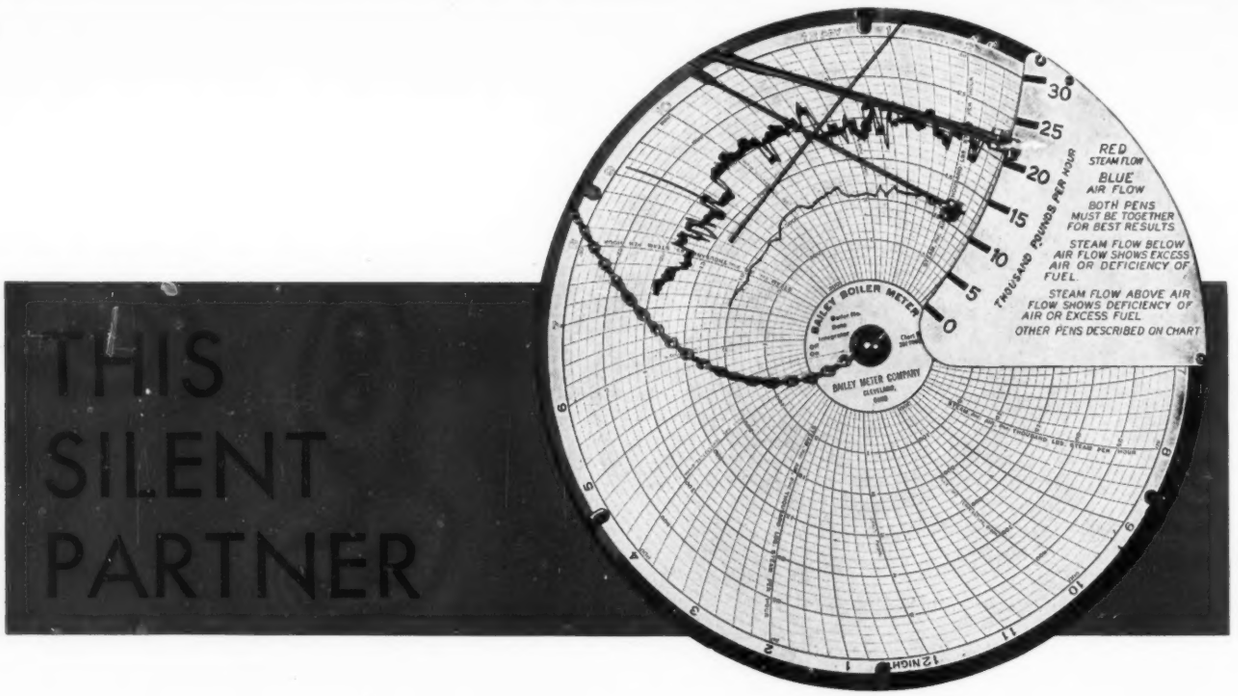
December 1933



. . . DIRECTS THE MODERN BOILER OPERATOR

Bailey Boiler Meter installed in a Mid-western industrial plant. The operator is making adjustments to keep the Air Flow and Steam Flow pens together.

THE modern boiler operator has a silent partner . . . the Bailey Boiler Meter . . . who directs him in his work.

Throughout his shift, the operator glances occasionally at the indicating scale and the records of the Bailey Boiler Meter. He knows that so long as the record of Air Flow coincides with that of Steam Flow, the correct amount of air is being supplied for efficient combustion. Should the pens separate, he merely adjusts the air supply until they are together again. The record of Flue Gas Temperature warns him of dirty tubes or leaky baffles.

No wonder that this silent partner is a close friend for the operator can do better work with less effort. He is proud of having increased both boiler efficiency and maximum capacity.

You will be interested to read of actual cases where Bailey Boiler Meters have quickly paid for themselves by lower fuel bills. Write for your free copy of bulletin No. 43a.

D-3

BAILEY METER CO.

1026 IVANHOE ROAD CLEVELAND, OHIO

Bailey Meter Company Limited, Montreal, Quebec

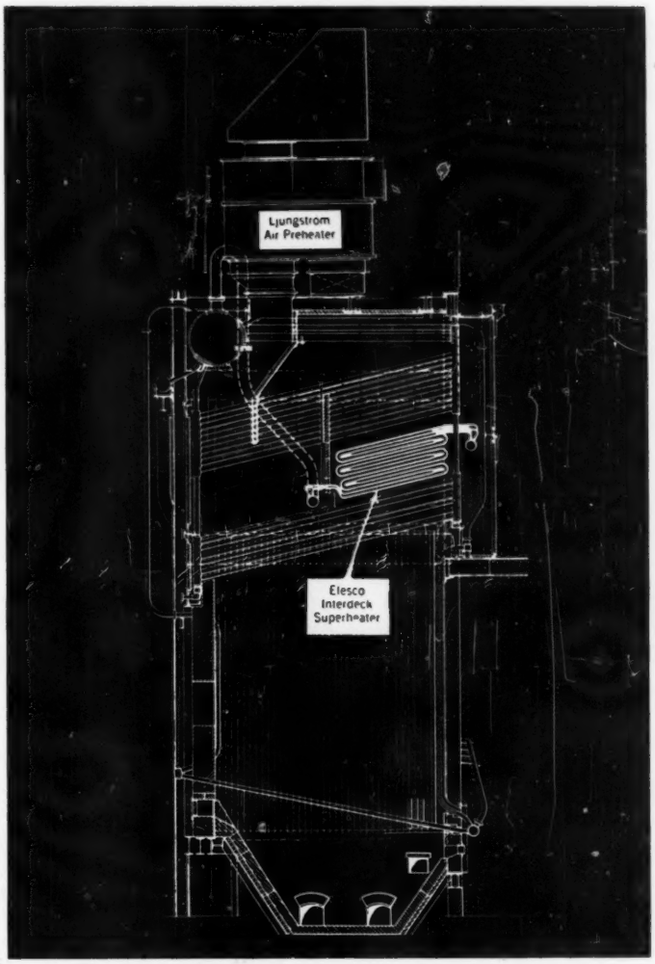
ELESCO SUPERHEATERS
LJUNGSTRÖM AIR PREHEATERS

in Lincoln Power Plant
of the
Boston Elevated Railway

This completely reconstructed plant, placed in operation during 1932, is representative of the latest power plant practice. It was designed especially for high efficiency with a high factor of availability; consequently important to its operation are the Elesco superheaters and Ljungstrom air preheaters, providing steam at higher pressure and temperature, and highly-preheated combustion air.

• • •

Both Elesco superheaters and Ljungstrom air preheaters embody the cumulative engineering and performance experience obtained from all types of steam power plants. Applicable to new or existing plants, they assure the utmost performance efficiency obtainable under the plant operating conditions.



Four 1148-hp. C-E sectional header (Walsh-Weidner type) boilers, pulverized coal fired, equipped with Elesco interdeck superheaters and Ljungstrom independent-fan type air preheaters for the following conditions:

Steam temperature	750 deg. F.
(Superheat	290 deg. F.)
Pressure	450 lb. per sq. in.
Evaporation	152,000 lb. steam per hr., from and at 212 deg. F.
Exit gas temperature	280 deg. F.
Preheated air temperature	550 deg. F.

THE SUPERHEATER COMPANY
THE AIR PREHEATER CORPORATION

60 East 42nd Street, New York

A-800

Representatives in all large industrial centers

REVOLUTIONARY

IN DESIGN

STARTLING
in performance

AMAZINGLY SMALL
in size

So extraordinary is the new Bulletin 709 across-the-line switch that all old ideas of starter sizes and switching capacities are out of date!

Here—a snug handful—is a solenoid-operated starter so small that it sets a new standard for compactness, and yet so big electrically that it successfully handles four times its maximum horsepower rating on 550 volts. It has no trouble-making bearings, flexible shunts, noisy clappers, bulky arc barriers, slate or molded panels, concealed wiring, and other clapper switch relics.

HERE IS THE TRULY MODERN STARTER!

The Bulletin 709 is correctly called "the starter that dared to be different." Know more about this pace setter and its distinct advantages! A new bulletin with surprising facts and dimensions is ready for you. Send for it, today.

ALLEN-BRADLEY

BULLETIN
709

SOLENOID-OPERATED
ACROSS-THE-LINE
A. C. STARTING SWITCH

POLYPHASE RATINGS

3 H. P. - - 110 Volts
5 H. P. - - 220 Volts
7½ H. P., 440-550 Volts

The Bulletin 709 Starting Switch comes in three forms: 1—with push buttons; 2—without push buttons; 3—with a two-way switch for hand and automatic control. The cabinets are decidedly attractive and allow generous space for all wiring.

THE MOTOR STARTER THAT DARED TO BE DIFFERENT

ALLEN-BRADLEY COMPANY,
1319 S. First St., Milwaukee, Wis.
☐ Please mail Bulletin 709.
☐ Please have A-B Sales Engineer demonstrate Bulletin 709 Starter.

Name_____

Address_____

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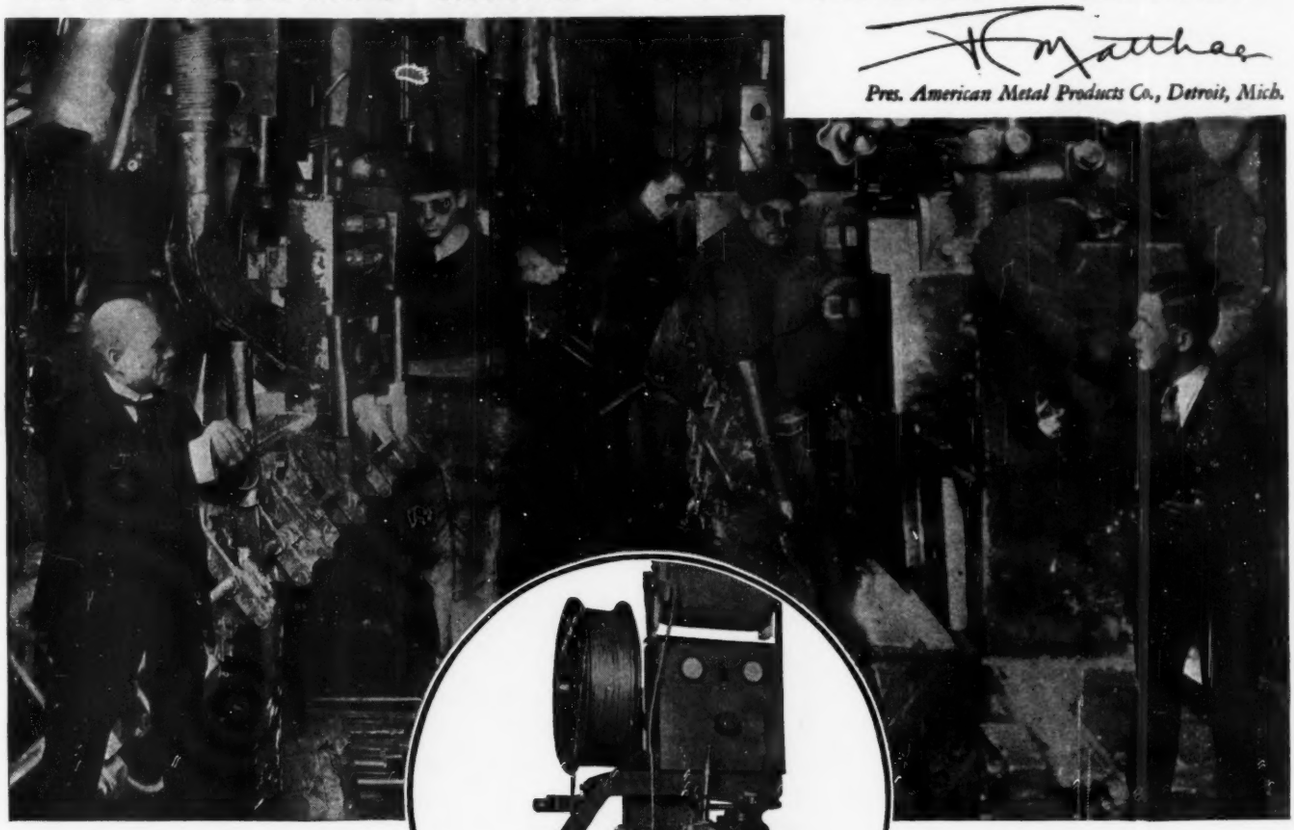
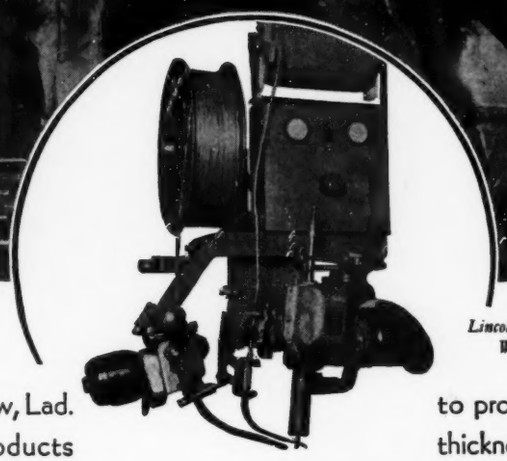


Pres. American Metal Products Co., Detroit, Mich.

Fourteen Lincoln "Electronic Tornado" automatic welders are in the weld production line at The American Metal Products Co., Detroit, Michigan.



Lincoln "Electronic Tornado" Automatic Welding Head with wire feeder.

"Mr. Matthaei ought to know, Lad. The American Metal Products Co. turns out daily 20,000 automotive parts such as torque tubes, brake cross shafts, mufflers and other tubular parts. You'll find their products on some of the better known cars and trucks."

"Yes, Pop, they know their welding. That's why they use the shielded automatic carbon arc process of welding exclusively. It allows them to produce tapered tubes of even wall thickness . . . a saving of 10% to 50% in material over seamless tubing.

"The welds produced by their Lincoln *'Electronic Tornado'* automatic welders are so strong and ductile that they can upset a tube end forming a flange four times thicker than the tube wall . . . also the welds withstand a 180° twist of the tubes."

● How do you know that arc welding cannot improve your products and lower your present costs? Why not ask Lincoln to make a study of your manufacturing operations. It will cost you nothing to find out. Write today to

What's NEW in Welding!

PROCEDURE HAND BOOK OF ARC WELDING DESIGN AND PRACTICE

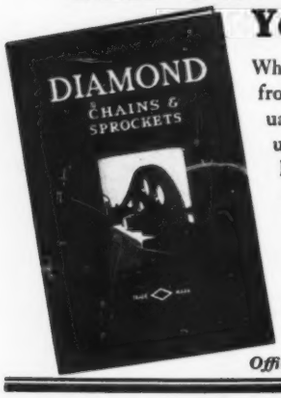
434 pages, $1.50—Write for description

LINCOLN

THE LINCOLN ELECTRIC COMPANY, CLEVELAND, OHIO

Largest Manufacturers of Arc Welding Equipment in the World W-52

This One Book Solves Your Drive Problems



Whether your problem is driving machines from a line shaft—driving from individual motors—driving or co-ordinating units of a machine—transmitting many horsepower or a few, over short centers or long, at high speeds or low—you will find the answer in this 96-page Diamond Drive "Encyclopedia." A copy will be mailed without charge.

DIAMOND CHAIN & MFG. CO.
413 Kentucky Ave., Indianapolis, Ind.
Offices & Distributors in all Principal Cities

November, 1933 MECHANICAL ENGINEERING Vol. 55, No. 11
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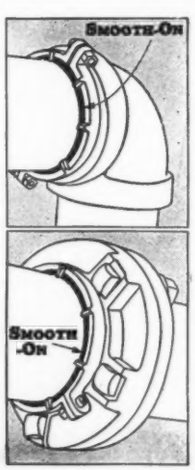
The way to stop pipe-thread leaks
SMOOTH-ON No. 1 in a
SMOOTH-ON CLAMP
No interference with the bolts and nuts of a flanged joint

Applying Smooth-On No. 1 in a Smooth-On Clamp as indicated in the diagrams avoids disconnecting the line and with a few minutes easy work stops leakage at threaded joints as completely as putting in new and perfect fittings—and the finished repair is so small that it is hardly noticeable. If the pipe is covered, the repair cannot be detected at all. Smooth-On Clamps should be stocked for all sizes of piping in the plant.



The Smooth-On Handbook is filled with instructions, diagrams and helpful hints on at least 200 uses of Smooth-On in routine and emergency repair work. Your repair kit is not complete without a small supply of Smooth-On No. 1 and a copy of this instruction book, which will be sent free on request.

Get Smooth-On Clamps in pipe sizes of from ⅜-in. to 12-in. and Smooth-On No. 1 in 1-lb. or 5-lb. can or 25-lb. or 100-lb. keg. If your dealer can't supply you, write directly to us.

SMOOTH-ON MFG. CO., DEPT. 56
570 Communipaw Ave., Jersey City, N. J.

SHAKEPROOF
FOUND! *a new way to save money!*

SOME time ago a smart designing engineer discovered that he could save money for his firm and provide better performance for his product by incorporating the Shakeproof locking principle into certain standard parts. Since then several leading manufacturers have also taken advantage of this practical idea.

Possibly you have a part on your product where this money-saving method can be employed. If you have, you should consult Shakeproof's engineers immediately. It saves the purchase of separate lock washers because the twisted teeth are built right into the part. Each tooth bites into both nut and work and there is no possible movement of the part regardless of how great is the vibration.

Send today for your free copy of this complete Shakeproof Catalog. Explains thoroughly the many advantages that Shakeproof offers—also shows new patented Shakeproof products.

Be sure to look into this new method for cutting costs—look over your product to see where it can be used and then write for a Shakeproof engineer to discuss the matter with you personally. No obligation, of course, so write us today!

SHAKEPROOF *Lock Washer Company*
(Division of Illinois Tool Works)
2511 N. Keeler Ave. Chicago, Ill.

U. S. Pat. 1,410,564—1,604,122—1,605,654—1,782,387 Other Pat. Pending—Foreign Pat.

Oxwelding helps « « «

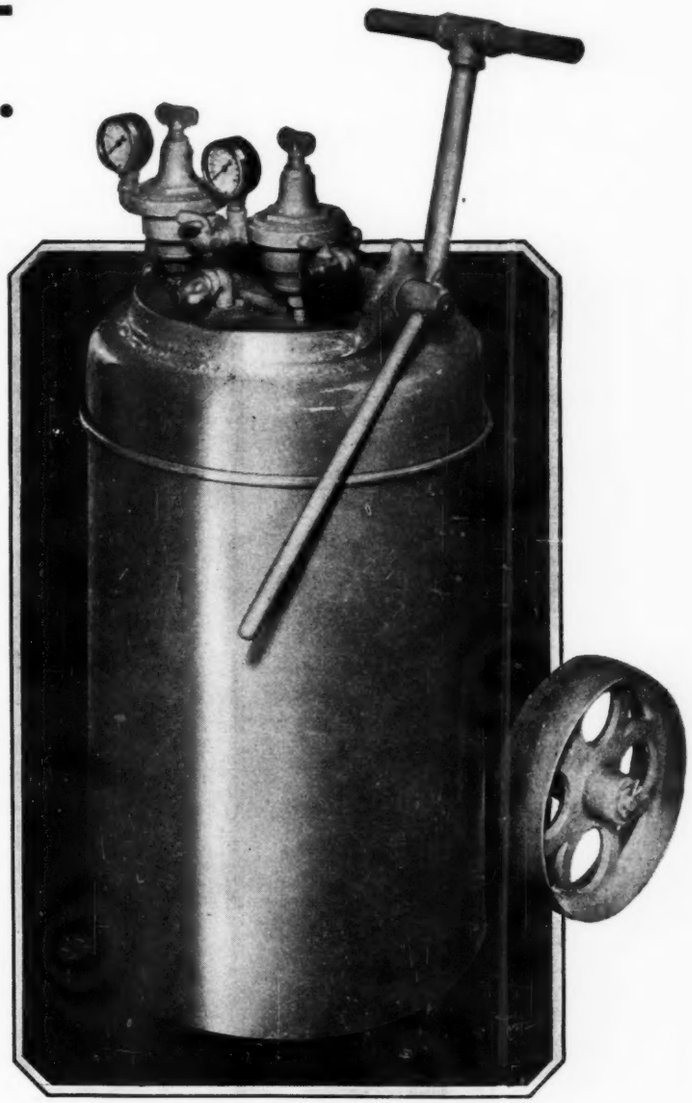
IN PROFITABLE REDESIGN . . . . .

OXWELDING has enabled many manufacturers to turn out better metal products, often at lower cost, because it offers economies in production as well as complete freedom in design. Oxwelded joints assure the full rated strength of steel, or other materials. They can be made smooth and flush,—finishing is quicker and less expensive.

For instance:—A manufacturer of paint spraying equipment wanted a better joint for attaching chrome-molybdenum flanges to steel tanks. An oxy-acetylene welded joint proved more efficient and less costly.

But this was only a beginning. A Linde representative proposed redesign for welding,—relocating the cover flange joint to permit welding from the inside. This eliminated grinding which formerly was necessary prior to painting the tank. The use of a bronze welding rod, which was also suggested, required 17 minutes less welding time per tank and gave ample strength.

If you feel that redesign might improve your product, ask any Linde District Office how to obtain the full benefits of oxwelding and cutting. Write or 'phone, now.



Welding reduced the cost of the cover flange joint in this paint sprayer 68 per cent. Finishing costs were reduced approximately the same.

NRA

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Unit of Union Carbide and Carbon Corporation

126 Producing Plants UCC 627 Warehouse Stocks

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3-D

LINDE OXYGEN • PREST-O-LITE ACETYLENE • OXWELD APPARATUS AND SUPPLIES • UNION CARBIDE

NUMBER THREE

of A Series of Advertisements Outlining Policies of

COMBUSTION ENGINEERING COMPANY, INC.

•

Numbers One and Two of this series outlined those *sales* and *engineering* policies of Combustion Engineering which have a direct bearing on its relations with customers. This, the concluding advertisement of the series, covers similar policies with respect to *manufacturing* and *service.*

POLI

MANUFACTURING POLICY

Combustion Engineering predicates its manufacturing policy on a major conception of its business which has been stated previously in this series; namely, *that future sales depend primarily on satisfactory installations.* One of the obvious essentials of a satisfactory installation is that the equipment be so manufactured that it can be relied upon to give dependable service. In the case of equipment which is vital to the basic processes of steam and power generation, the importance of the factor of *dependableness* is self-evident.

Another essential of a satisfactory installation is that the equipment be so constructed as to assure minimum maintenance costs, not merely for a year or two but throughout its reasonable lifetime.

These considerations make apparent the logic and commercial soundness of Combustion Engineering's manufacturing policy which, briefly stated, is to turn out the best work which *exacting standards, well trained workmen, complete and modern equipment, the use of the best materials* and *adequate inspection and testing facilities* will permit.

It is one thing to state such a policy; it is quite another to be able to carry it out. Combustion Engineering has not only the purpose but also the facilities to do so.

Its manufacturing plant at Monongahela, Pa., is second to none of its class in the country. This applies to all its departments,—foundry, pattern shop, machine shop, sheet metal shop, etc. The automatic welding department at Monongahela is one of the most completely equipped of its kind. The products manufactured at this plant include all types of stokers, pulverized fuel burners, feeders, etc., air preheaters, water-wall tubes and miscellaneous castings.

The company's boiler shops at Chattanooga, Tenn., are known for the completeness and excellence of their facilities,—foundry and pattern shops, plate shop, sheet metal shop, machine shop and forge shop. Particularly notable at this plant are the specially-designed annealing furnace used in connection with welded drums and pressure vessels, the X-ray testing facilities for welded vessels and the metallurgical laboratory which is fully equipped to handle any research or test problems on base metals or alloys.

C I E S

The company's plant at Chicago is fully equipped for its specialized work of manufacturing Raymond pulverizers and milling equipment.

These manufacturing facilities permit the complete fabrication and testing of Combustion Engineering equipment under full control at all times, thus assuring the company's ability to carry out its policy.

SERVICE POLICY

It is Combustion Engineering's policy to regard *service* as involving all field work, i. e., installation of equipment, placing equipment in operation and training plant operators, and subsequent field service. These functions are carried out under the same supervision for the reason that the men responsible for installation and placing in operation are familiar with every detail of the equipment and are well qualified to do any subsequent service work that may be necessary.

Obviously, this grouping of functions requires a highly skilled and experienced field staff. Combustion Engineering service men are trained to meet this requirement and can be relied upon to exercise care and intelligence in every phase of their work. The fact that they are responsible for the satisfactory operation of a job assures their conscientious attention to the details of its installation and the training of plant operators. Their experience has taught them that proper installation and "starting up" of equipment are essential to satisfactory operating results.

All service work is done under the supervision of field superintendents who are stationed at centrally located points to assure prompt service. When unusual problems are encountered, these men may call upon special service and staff engineers who are experts in the various phases of boiler room operation.

Combustion Engineering's service policy shares with all other company policies a common purpose,—*to make every C-E installation a reference plant.*

COMBUSTION ENGINEERING COMPANY, INC.
200 Madison Avenue, New York
Canadian Associates, Combustion Engineering Corporation, Ltd., Montreal

A-107

COMBUSTION ENGINEERING PRODUCTS

BOILERS

C-E Sectional Header Boiler
C-E Box Header Boilers
C-E Bent Tube Boilers
C-E H.R.T. Boilers
C-E Electric Boilers

STOKERS

C-E Multiple Retort Stoker
Type E Underfeed Stoker
Type E Stoker-Unit (*for small boilers*)
Type H Stoker (*for industrial furnaces*)
Coxe Traveling Grate Stoker
Green Chain Grate Stoker (*natural draft*)
Green Chain Grate Stoker (*forced draft*)

PULVERIZED FUEL

Lopulco Storage System
Lopulco Direct-Fired System
Raymond Pulverizing Mills

WATER-COOLED FURNACES

C-E Water-Cooled Furnace
Lopulco Water Screen
C-E Slagging Furnace

COMPLETE UNITS

Coordinated designs comprising any combination of boiler and firing equipment and
Combustion Steam Generator (*a standard unit for medium-sized and large plants*)
C-E Steam Generator Unit (*a standard unit for small plants*)

OTHER EQUIPMENT

C-E Air Preheaters (*plate and tubular types*)
C-E Economizer
Quinn Oil Burners
Grieve Grates
C-E Ash Conveyors
C-E Ash Hopper

ENGINEERING

MECHANICAL ENGINEERING

TABER PUMPS

DURABILITY RELIABILITY

CARRIED in STOCK

Through the interchange of impellers Taber standard single suction Centrifugal Pumps serve also as custom-made pumps . . . and shipment is made from stock.

Whether you need a standard or a special pump . . . send your inquiry to Taber to know how well and how quickly you can be served. Write for comprehensive Bulletin No. G-631.

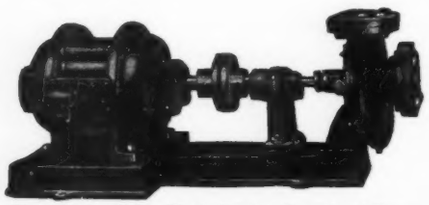

Fig. 190-A. Taber Single Suction Centrifugal Pump

TABER PUMP Co.
ESTABLISHED 1859
292 Elm St., Buffalo, N. Y.

Just like opening a book

The Genuine for accessibility

Squires STEAM TRAP

It's about as easy to get into a Squires Steam Trap as opening a book. Removal of two bolts frees the top cap—and the valve and seat are completely exposed to view.

The accessible Squires has become a byword among power plant operators. Reliability and economy are among its popular points and besides Squires Traps positively will not wire draw. Our guarantee is for pressures up to 300 lbs.

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E. 40th St. and Kelley Ave.
Cleveland, Ohio

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Reg. U. S. Pat. Office

May we send you catalog H-9?

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Horizontal Cross Drum Boilers
Vertical Water Tube Boilers
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BOILERS

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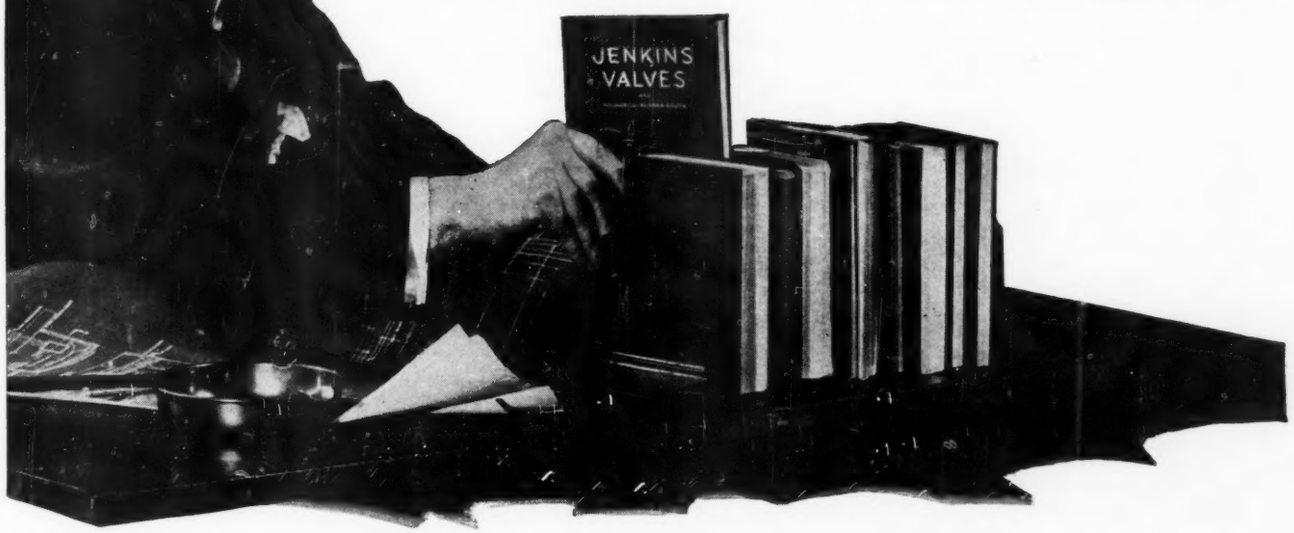

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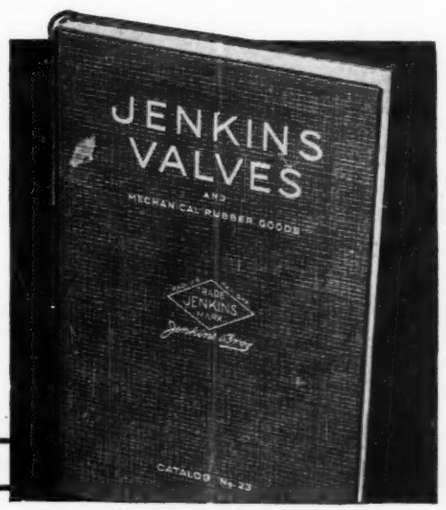

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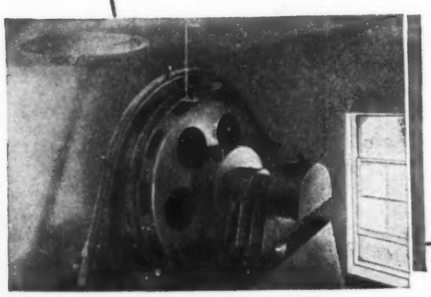

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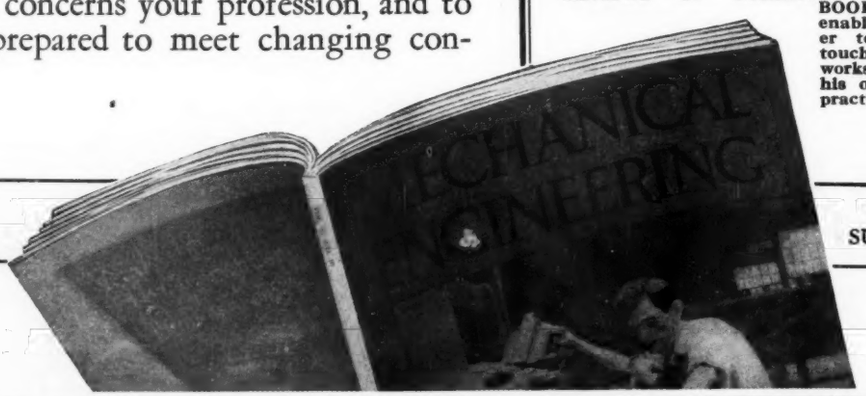

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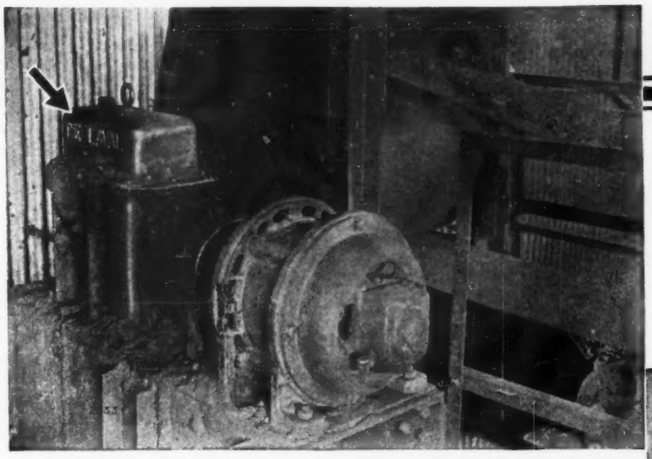

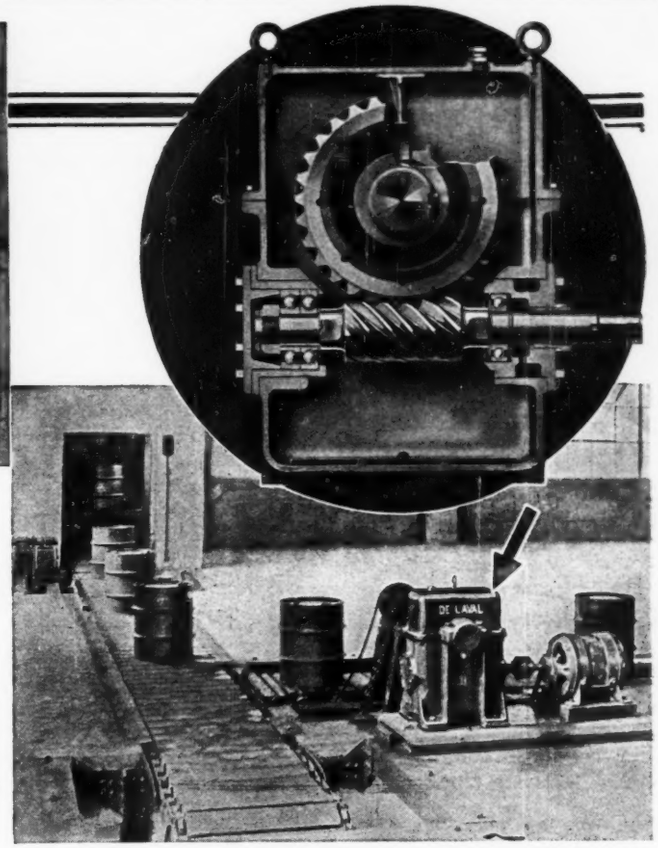

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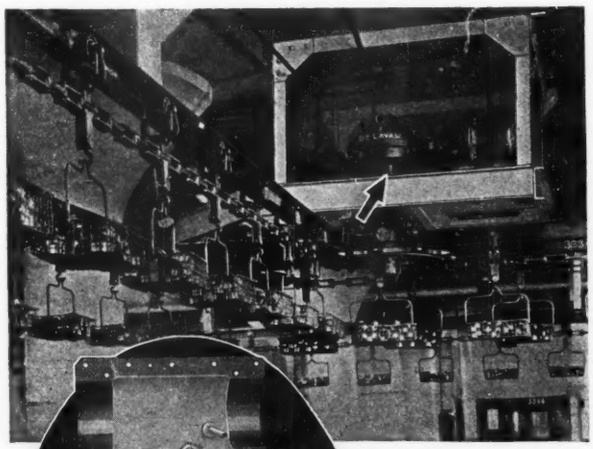

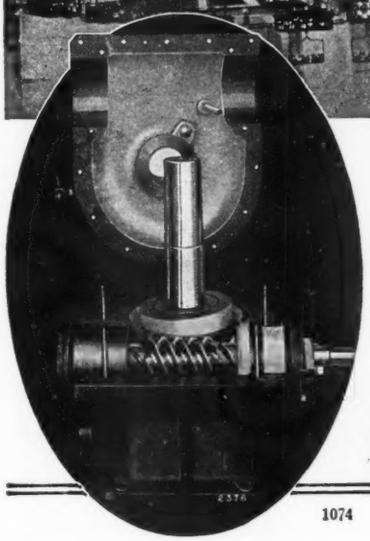

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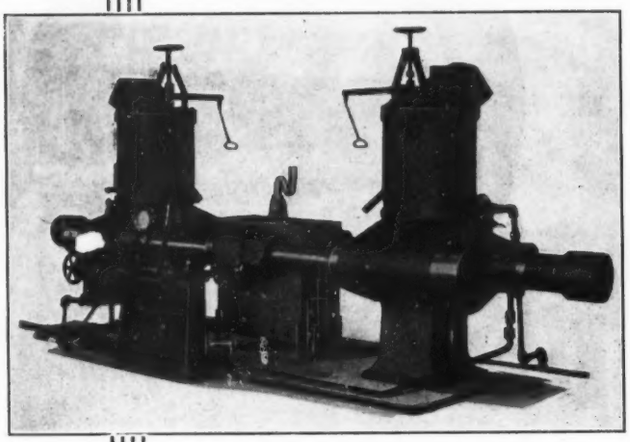

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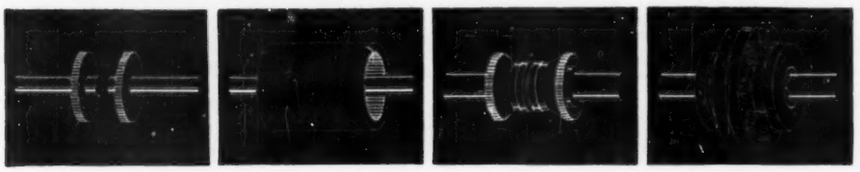

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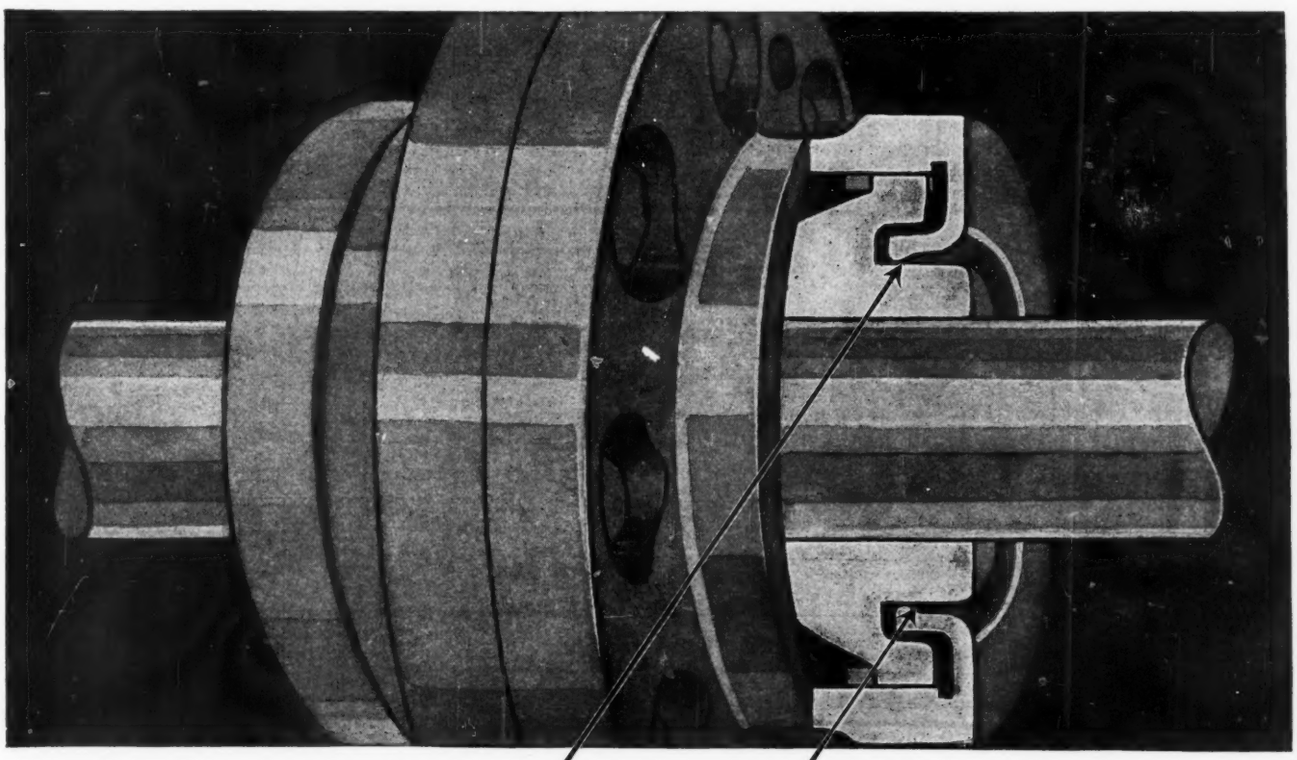

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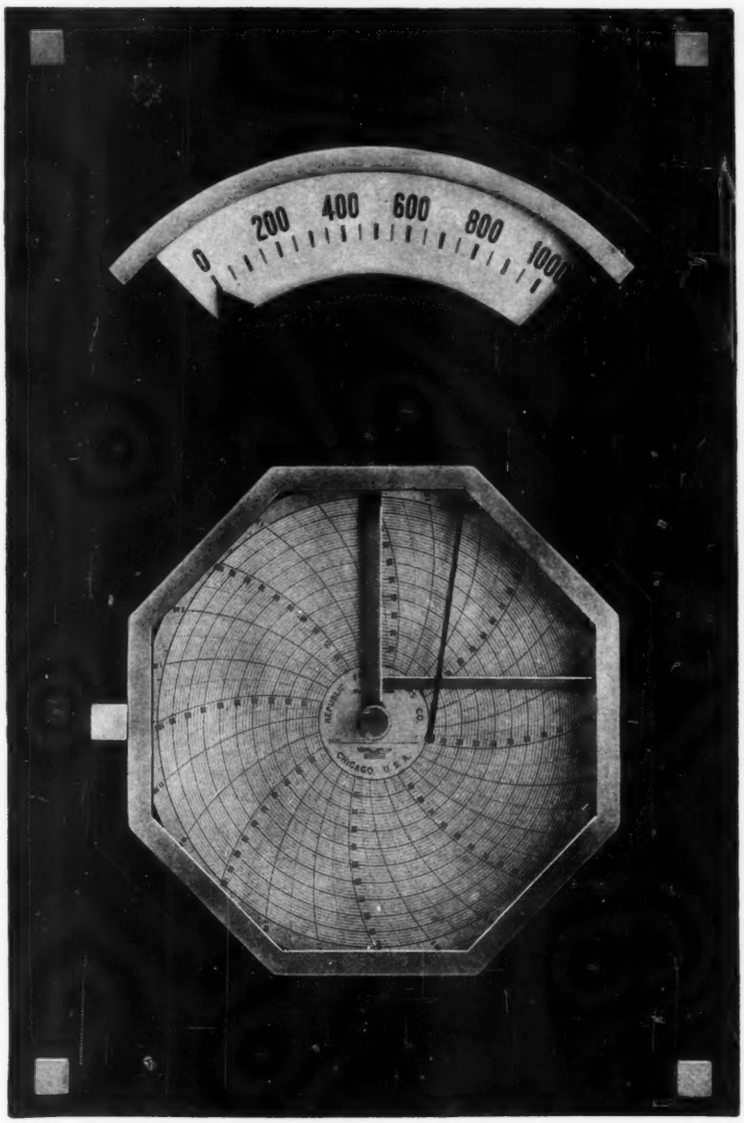

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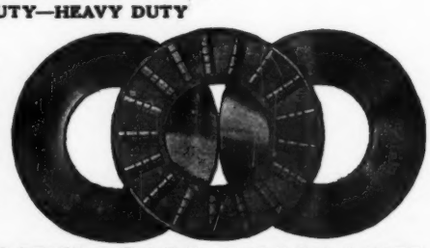

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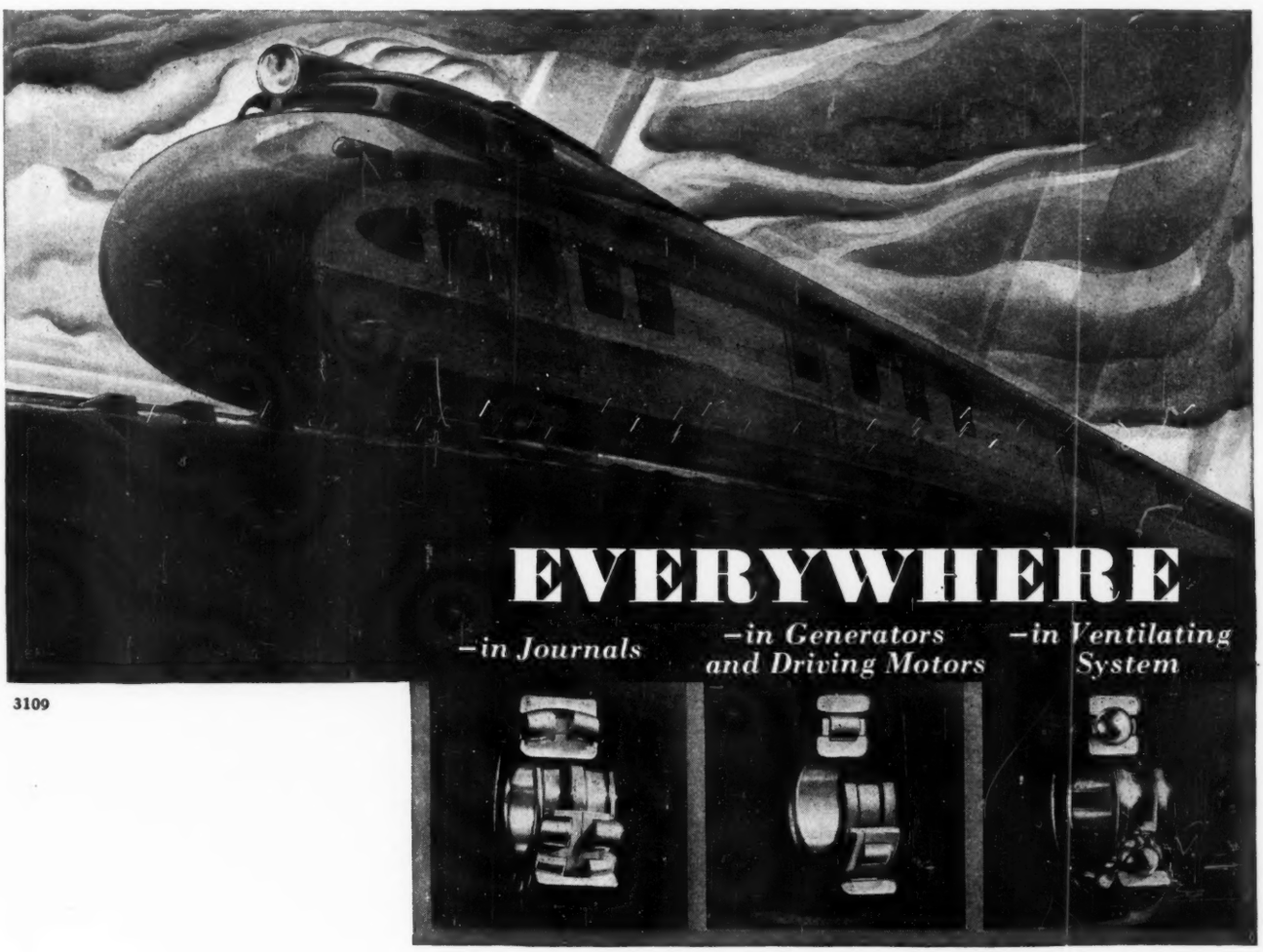

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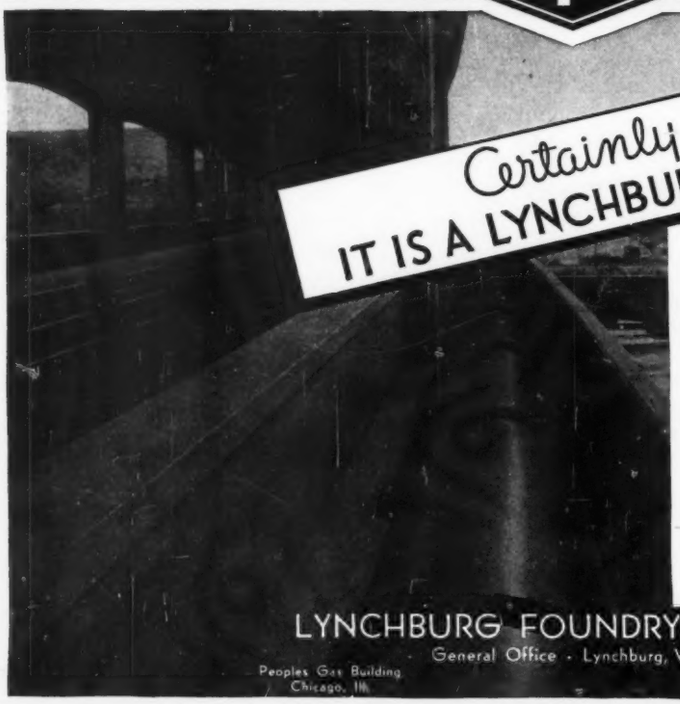

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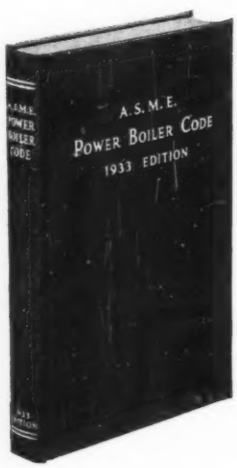

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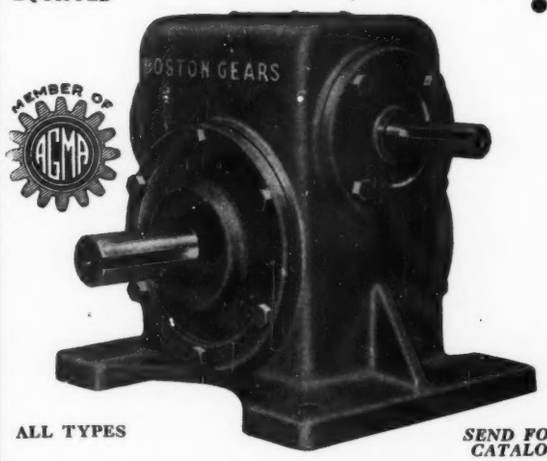

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The Open Door

of the

NEW YORK CITY CANCER COMMITTEE

34 East 75th Street, New York, N. Y.

To this open door last year over two thousand people came seeking, and received, free advice and help.

Keep this door open in 1934.

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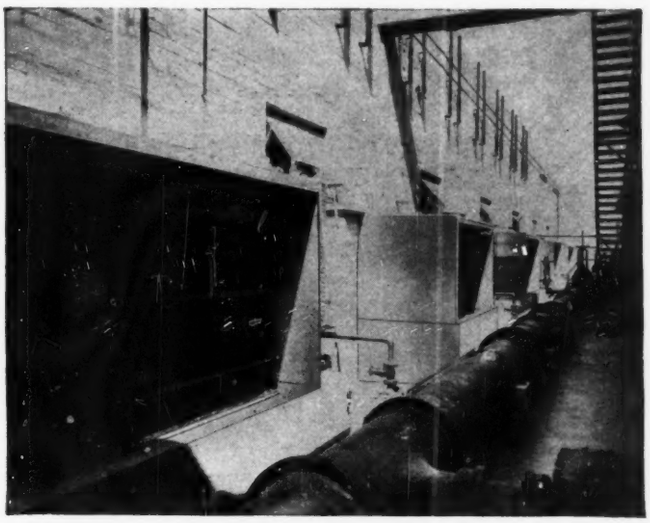
The sale of these labels and voluntary contributions are the Committee's only source of income in its work of helping those victims of cancer who are unable to help themselves.

Will you help?

Pamphlets and other information are furnished free on request. Write or telephone to the address above, or, if you live outside the Metropolitan area, to the American Society for the Control of Cancer, New York, N. Y.

Washed Air *for* Industry

Washed air means really CLEAN Air and in many industrial plants clean air is an asset worth thousands of dollars a year. Buffalo Air Washers not only CLEAN the air, but they temper it uniformly thruout the heating season, and in most installations provide warm weather cooling to a considerable degree. Buffalo Air Washers are efficient and economical to operate. They require practically no maintenance and last a lifetime.



Five Buffalo Air Washers Clean the Air for New Vernon Municipal Diesel Plant.

Because we maintain one of the largest engineering organizations in the industry, Buffalo Air Washers are provided with many refinements found in no other type of equipment. Used in process plants to eliminate floating dust, in food factories for sanitary reasons, in "Death Valley" to overcome the extreme heat, and in many other installations of like nature, Buffalo Air Washers have made enviable operating records of fifteen to twenty years' duration. Before you purchase any air cleaning equipment, get the full story of "Buffalo" Air Washers.

BUFFALO FORGE COMPANY

148 Mortimer St., Buffalo, New York

In Canada: Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

"Buffalo" AIR WASHERS

A Word About Firms who have abridged catalogs in the 1933-34 MECHANICAL CATALOG

(No. 3 of a series)

United States Hoffman Machinery Corp'n. 103 Fourth Ave., New York, N. Y. Manufactures diversified group of machinery products. Known for thirty years as largest manufacturer of garment pressing machines. Hoffman miniature steam boilers lead all others in sales. Hoffman washing machines, high speed centrifugal extractors and drying tumblers widely used in laundry and dry cleaning industries. Long experience with centrifugal blowers and vacuum producers. Recently introduced Hoffman centrifugal blowers and exhausters, Hoffman vacuum sweeping systems for heavy duty industrial service. Most complete range of sizes and capacities. Centrifugal products designed and built in Hoffman factory by engineers with many years of specialized experience in this field.

Westco Pump Corp'n, Gaines & Front Sts., Davenport, Iowa. Westco engineers originated the Turbine-type pump which is well-known for its ability to produce higher pressures in single stage at standard motor speeds and for its wide operating range characteristic. This company maintains a staff of engineers whose experience covers many years and embraces practically every type of pumping problem. Completely fitted laboratories of the most modern type are at the disposal of these men for development work and for rendering practical and technically reliable assistance to prospects and customers. Products made include Westco Standard Turbine Pumps, Hot Oil Pumps, Sanitary Pumps, Condensation Pumps and Receivers, Automatic Water Systems, Deep Well Pumps, and Underwriters' Laboratories Approved Tank Filling Pumps. Westco Branches are located in New York, Philadelphia, Chicago, Los Angeles, and San Francisco. Distributors in 50 principal cities.

Nash Engineering Co., 201 Wilson Road, South Norwalk, Conn. Established in 1905, this engineering organization has, so far, devoted its energies entirely to the perfection and manufacture of improved pumping machinery for handling air, other gases, and liquids. This company started as a manufacturer of the now well-known Nash Hytor, or Hydro-turbine Air Compressors and Vacuum Pumps. The line has been extended whenever a really superior design could be offered to the market. It now includes the Jennings Return Line Heating Pumps, Condensation Pumps, Sump and Sewage Pumps, Sewage Ejectors, and Centrifugal Pumps.

Northern Equipment Co., 2320 Grove Drive, Erie, Penna. Manufacturers of the "Copes" System of Boiler Feed Control and allied products. Has specialized in feed water regulation under present management since 1913. Pioneered the continuous-feed-stabilized-water-level principle of boiler feeding, differential pressure control, the use of feed water regulators for pressures greater than 1000 pounds and other important contributions to modern boiler feed control. Worldwide experience and a well-trained engineering staff have made the "Copes" Regulator the recognized standard for performance. In recent years a complete line of liquid level controllers and flow and pressure controllers has been developed around the accurately balanced "Copes" Control Valve.

Moore Steam Turbine Corp'n, Wellsville, N. Y. Manufacturers of Steam Turbines and Reduction Gears since 1916. Makes both single stage and multi-stage turbines of all types up to about 3000 horsepower, with a line of reduction gears for use when necessary to adopt turbines of economical speeds to the correct speed for the driven machines. Special attention is paid to turbines which require consideration of both power and process steam requirements, such as bleeder, mixed-pressure, mixed-pressure-bleeder, high back pressure turbines, etc. A flexible design and manufacturing system is combined with a policy of giving skilled and painstaking engineering attention to each individual turbine. Exceptional testing facilities are available and every turbine, large and small, is thoroughly tested under load before shipment.

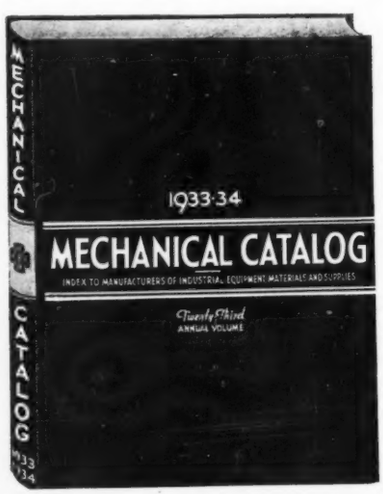
Busch-Sulzer Bros.-Diesel Engine Co., St. Louis, Mo. Engaged in designing and building Diesel Engines, with adequate technical staff and specially equipped Diesel works; guided in design, selection of materials, and workmanship by over thirty years of its own experience in building Diesel Engines, both 4- and 2-cycle types, heavy duty slow speed, special light weight high speed, including stationary and marine reversing Diesels; under the direction of Dr. Diesel until 1913; by 15 years (1911–1926) of technical collaboration with the Swiss firm, Sulzer Brothers; and, at present, by the engineering research and technical advice of Allgemeine Elektricitats Gesellschaft, of Germany, builders of the first successful solid injection double-acting 2-cycle Diesel.

Dayton-Dowd Co., Quincy, Illinois. From a modest beginning a quarter of a century ago has grown the present extensive line of Dayton-Dowd centrifugal pumps, in single and multi-stage designs, for virtually every pumping service. Dayton-Dowd builds centrifugal pumps exclusively and is a completely integrated plant, having its own engineering department, pattern shops, iron and brass foundries, machine shops, assembly shops, and one of the most up-to-date hydraulic laboratories in the country. The line comprises centrifugal pumps only, from 3/4" to 60" discharge. No other type of pump occupies our attention or facilities.

Grant Gear Works, Inc., Second & B Streets, Boston, Mass. Founded in 1877 by George B. Grant, the "pioneer Gear man" to manufacture better Gears. The business developed so that in a few years the first stock Gear catalog in this country was issued. Today this catalog has 150 pages and contains Gears, Sprockets, Reduction Units, etc., and many useful and interesting tables on horse power, etc.

Newport News Shipbuilding & Dry Dock Co., Newport News, Va. Was incorporated in 1890, and has been in continuous operation, engaged in general shipbuilding and ship repairing; marine boiler, engine and turbine building. The scope of contracts executed and on order covers all sizes of merchant and Naval ships. In 1922 the building of hydraulic turbines and accessory equipment, including head gates, crest gates, penstocks, butterfly valves, rack rakes, etc., was added as a permanent part of the business, and installations of largest sizes and capacities have been made. A large hydraulic laboratory completed in 1933 replaces the original testing flume built about ten years ago, and affords unsurpassed opportunities for research. A large and experienced designing staff and modern shops with ample equipment for handling the largest work assure successful products in the shortest time consistent with high quality.

Allis-Chalmers Mfg. Co., Milwaukee, Wis. Builders of a large variety of power, electrical, industrial, and agricultural machinery. This company, formed by a consolidation of leading pioneer firms in 1900, has experience extending over eighty years, with installations of engines, turbines, and water-wheels aggregating seventeen million horsepower; pumps of total capacity eight billion gallons per day; and machinery for rock and ore plants, flour, and lumber mills, etc., the world over. Recent acquisitions and developments have greatly widened the diversified line of products enabling Allis-Chalmers to serve many industries; to share in the electrification of industry and railways and to supply tractors, farm, and road machinery.



The only specialized reference annual for the buyer and specifier of mechanical equipment and engineering materials—contains the essential data of outstanding firms whose products are of interest to engineers and engineer-executives.

Simplex Valve & Meter Co., 6755 Upland St., Philadelphia, Pa. This company was established by J. W. Ledoux in 1905 for the purpose of manufacturing meters of the differential head type utilizing the Ledoux Bell, a mechanism for translating flows of liquids through primary devices, such as pitot and Venturi tubes, into straight line motion. Since its founding, the company has become one of the most widely recognized manufacturers of water purification, sewage treatment, and metering equipment. Among the many devices now in general use are the Simplex Effluent Rate Controllers, the Simplex Filter Gages, the Simplex Air Release, and Air and Vacuum Valves.

Wright Manufacturing Division of American Chain Co., Inc., York, Penna. Started as the Wright Manufacturing Co. at Lisbon, Ohio, about 1895, their reputation for precision machinery brought to them requests for hoisting equipment, and they gradually worked into the chain hoist field, later adding the Spur-Geared and Differential types, together with Hand Traveling Cranes, Jib Cranes, etc. In 1928 they became associated with the American Chain Co., Inc. Their latest developments include a ball-bearing type Differential Hoist and a new Malleable Iron Spur-Geared Hoist.

The Medart Company, 3504 DeKalb St., St. Louis, Mo. Nationally recognized as one of the foremost manufacturers of Power Transmission Machinery of all kinds. Established 1879 as the Medart Patent Pulley Co. The shops and foundry now occupy five city blocks in the City of St. Louis, Missouri. This company also manufactures turned and polished shafting. Shaft Turning and Polishing Machinery, in use in the majority of cold finishing steel mills in the country today, has been built by the Medart Company. The St. Louis Shafting Mill of this company is one of the oldest in the United States. The products also include special machinery, alloy iron castings and other specially engineered products for oil, textile, paper, chemical, and other industries. The first steel rim, steel arm pulleys made in the United States were made by this company.

Dean Hill Pump Co., Anderson, Indiana. The present line of Dean Hill Pumps is the result of nearly half a century of progress in designing and building high grade equipment. Experience gained during that time has enabled its engineers to apply centrifugal pumps to practically every industry. New materials together with new developments have opened many new fields of application and now there is a pump for handling any liquid that will flow. The company maintains offices in principal cities, with competent engineers in charge who are glad to assist and advise on pumping problems.

Detroit Hoist & Machine Co., 8201 Morrow St., Detroit, Mich. In business over 28 years, this company is one of the pioneers in the manufacture of small power hoists. The early years of manufacturing were confined to the Geared Pneumatic type of Hoists, Cranes, etc., many of which are still in successful operation. For over twenty years the line has also included Electric Hoists, Cranes and Overhead Hoisting Appliances, embracing a line of cranes of standard and special design from one to ten tons capacity. This firm has its product widely distributed and has enjoyed a healthy business experience, never having changed its management or policies.

Crane Co., 836 South Michigan Ave., Chicago, Ill. Makers of valves, fittings, piping, and specialties—for steam, oil, air, water, and gas—and of plumbing and heating materials for home, commercial, and institutional use. Pioneers in the study and development of metals and designs for piping materials to control high temperatures and pressures. Founded 78 years ago this company has grown from a modest beginning to a globe-girdling organization serving every part of the earth with dispatch.

Babcock & Wilcox Co., 85 Liberty St., New York, N. Y. Since 1867, when the patent was granted for the original Babcock & Wilcox boiler, the history of the company has been one of steady growth and progress. The present company was incorporated in 1881, the year of the birth of the electric generating station. Boiler units are now built in all sizes, complete in every important respect, and other products, of the company and its subsidiaries include process equipment, seamless tubular products, and refractories. The motive of the company has always been, and is, that of giving the best and most satisfactory service; of furnishing the best in ideas, information, material, and workmanship; of justifying the faith of its customers.

PROFESSIONAL SERVICE

RATE $2.00 per month to A.S.M.E. members, $2.50 per month to non-members, which includes name and address in Alphabetical List and one listing in Classified List. Additional listings $1.00 each per month to A.S.M.E. members, $1.25 each per month to non-members.

THE feature of this section is the Classified Index of specialists, which is arranged alphabetically by subject headings. The method of classification is to list by specific specialty offered and sub-list by function performed. The advice or services of experts thus is assured without delay or confusion.

When seeking information about a given specialty, for example, regarding a Steam Power Plant, look under "POWER PLANTS, STEAM" and under this heading and its subheadings are listed those specializing in the design, location, supervision, layout, test, etc., of such a project. Select one or more names and refer to the Alphabetical List in the center of the page for addresses.

CONSULTING ENGINEERS • ENGINEERING ORGANIZATIONS • CONSTRUCTORS—CONTRACTORS • PATENT LAWYERS • ETC.

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TO SPECIALIZED SERVICES OFFERED

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Scovell, Wellington & Co.

Alkali Manufacturing Plants (Operation)
Ahlqvist, Harald

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Budgets (Preparation)
Scovell, Wellington & Co.

Buildings, General (Construction Supervision)
Murray, Thomas E. (Inc.)

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Murray, Thomas E. (Inc.)

Chemical Analysis
Pitkin, Lucius (Inc.)

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Fuel Engineering Co. of New York
Murray, Thomas E. (Inc.)

Cost Systems (Factories)
Scovell, Wellington & Co.

Electrical (General)
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Equipment
(See Buildings, Chemical Works, etc.)

Examinations, Investigations and Reports
(See Specific Specialty)

Factories
(See Specific Type desired)

Feed Water Treating Methods
Rice, Cyrus Wm., & Co. (Inc.)

Fuel, Laboratory Testing
Fuel Engineering Co. of New York

Fuel, Selection for Steam Plants
Fuel Engineering Co. of New York

Fuel Utilization Methods
(See Combustion)

Furnaces, Water Cooled (Construction Supervision)
Murray, Thomas E. (Inc.)

Furnaces, Water Cooled (Design)
Murray, Thomas E. (Inc.)

Heat Treating Methods
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Hydro-Electric (Development)
(See Power Plants, Hydroelectric)

Industrial (General)
(See Specific Specialty)

Industrial Plants (Construction Supervision)
Murray, Thomas E. (Inc.)

Industrial Plants (Design)
Murray, Thomas E. (Inc.)

Machinery or Machines
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Management (General)
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Manufacturing Methods and Processes
(See Specific Specialty)

Market Research
Arms & Madeheim

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(See Specific Specialty)

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Pitkin, Lucius (Inc.)

Metallurgical Analysis
Pitkin, Lucius (Inc.)

Metallurgical Research
Pitkin, Lucius (Inc.)

Mills (Design)
(See Specific Specialty)

SPECIALISTS

LISTED IN CLASSIFIED INDEX

Harald Ahlqvist, 331 Madison Ave., New York, N. Y.

Arms & Madeheim, 33 West 42nd St., New York, N. Y.

Sterling P. Buck, 629 F Street, N.W., Washington, D. C. Tel. District 3863.

Fuel Engineering Co. of New York, 116 East 18th Street, New York, N. Y.

Everett E. Kent, 75 Federal St., Boston, Mass. Tel. Hubbard 0234.

Robert E. Kinkead, 3441 Lee Road, Cleveland, Ohio.

A. A. Langewald, Jr., 86 Essex St., Boston, Mass.

Thomas E. Murray, Inc., 88 Lexington Ave., New York, N. Y.

Lucius Pitkin, Inc., Pitkin Bldg., 47 Fulton St., New York, N. Y.

Cyrus Wm. Rice & Co., Inc., Highland Bldg., Pittsburgh, Pa.

Sargent & Lundy, Inc., 20 North Wacker Drive, Chicago, Ill.

Scovell, Wellington & Co., 10 East 40th Street, New York, N. Y. Other Offices—Boston, Springfield, Mass., Syracuse, Philadelphia, Cleveland, Chicago, Kansas City, San Francisco.

Maxwell E. Sparrow, 1482 Broadway, New York, N. Y.

John A. Stevens, Inc., 16 Shattuck St., Lowell, Mass.

E. P. Worden, 1 Hamilton Road, Glen Ridge, N. J.

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Kent, Everett E.
Sparrow, Maxwell E.

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Arms & Madeheim
Buck, Sterling P.
Kent, Everett E.

Patent Investigations
Buck, Sterling P.
Kent, Everett E.

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Kent, Everett E.

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Kent, Everett E.

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Langewald, A. A., Jr.
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OPPORTUNITIES

Help Wanted—Positions Wanted
Equipment, Material, Patents,
Books, Instruments, etc.
Wanted and For Sale

RATES Classified advertisements under this heading in MECHANICAL ENGINEERING are inserted at the rate of 60 cents a line, 50 cents a line to members of A.S.M.E. Seven words to the line average. A box number address counts as one line. Minimum insertion charge, 5 line basis; maximum 20 lines. Display matter carried in single column units of multiples of one inch at the flat rate of $10. per inch per insertion. Copy must be in hand not later than the 10th of the month preceding date of publication.

REPRESENTATIVES AVAILABLE

MANUFACTURERS REPRESENTATIVES, Sales Engineers desire additional lines to sell to industrial concerns, power plants, etc., in Pittsburgh district. Our salesmen cover Pennsylvania west of Harrisburg, West Virginia and Ohio. Very best connections. Address CA-63, care of "Mechanical Engineering."

SALES ENGINEER—would like to represent additional manufacturer on commission basis with exclusive arrangement. Established contacts ten years in Wisconsin territory. Office in Milwaukee. Now handling high class product sold to machinery manufacturers and industrial plants. Member A.S.M.E. Address CA-59, care of "Mechanical Engineering."

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DESIGN ENGINEER, M.E., in field of refrigeration and air conditioning desires position of responsibility. Nine years practical, designing and testing experience. Address CA-66, care of "Mechanical Engineering."

MECHANICAL ENGINEER, University graduate, good organizer, successful record in executive positions, broad technical and administrative background, major experience obtained in chemical plants, sugar mills and with chemical equipment manufacturers, well versed in appraisal work, having command of several languages and free to travel, seeks position in U. S. A. or its Possessions. Address CA-67, care of "Mechanical Engineering."

EXECUTIVE—GRADUATE ENGINEER (M.E., M.S.M.E.) age 35. Thorough Industrial Engineering training including production, methods, time study, cost accounting, budgeting, and sales. All replies confidential. Address CA-60, care of "Mechanical Engineering."

ENGINEERING ASSISTANT TO EXECUTIVE: Broad experience in design, production control, advertising in shop and power plant in metal working plants and electric public utilities. Graduate M. E. of one of the leading universities of the country. Address CA-62, care of "Mechanical Engineering."

MECHANICAL ENGINEER, 46, twenty years' experience in design and development of heavy duty Diesel Engines, single and double acting two cycle Gas Engines—gas injection type—oil field Pumping Engines convertible to Gas or Diesel, direct connected Gas, Air, Ammonia, and CO_2 Compressors, research work, testing, etc., desires connection with progressive concern. Address CA-55, care of "Mechanical Engineering."

PATENT ATTORNEYS

PATENT LAWYER, MAXWELL E. SPARROW, Patent, Trade-mark, and Copyright Cases, 1482 Broadway, New York. N. Y.

JOHN P. NIKONOW, Mechanical and Electrical Engineer, Registered Patent Attorney. Member A.S.M.E., A.I.E.E., S.A.E., El.Chem. Soc. Patents in all countries. Consulting service on scientific and designing problems. 3425 Giles Place, New York, N. Y.

ENGINEER: MANUFACTURER: SPECIAL services in PATENT matters, I offer you at modest fees. Sterling P. Buck, a Patent Attorney; Registered 27 years in U. S. Patent Office; Registered in Canadian Patent Office; prompt, adaptive, persistent, thorough. Washington Permanent Bldg., Washington, D.C.

EDWARD GOTTLIEB, REGISTERED PATENT ATTORNEY, Associate Member A.S.M.E. Expert in patent causes. Consultations invited without obligation. Low fees, send for price list of charges. 5 Beekman Street, New York, N. Y.

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FOR SALE—VARIABLE DISPLACEMENT PUMP, patented, heavy pressure. Address CA-61, care of "Mechanical Engineering."

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BUSINESS OPPORTUNITIES

RESEARCH by well-known engineer has resulted in new process and machine revolutionizing staple industry. $15,000 will equip and operate plant to earn $25,000 to $50,000 net annually. F. A. W., care of C. W. Baker, 90 West St., New York. N. Y

MECHANICAL ENGINEER — forty-two — abroad — available United States February or June—wishes then to interview a manufacturing executive, confronted with inefficient plant operating problems and interested in securing someone suitable, to: investigate technically his power and manufacturing conditions, recommend resulting profitable possibilities, and execute approved projects into operation. Negotiations confidential. Address CA-65, care of "Mechanical Engineering."

EMPLOYMENT AGENCIES AND SERVICE BUREAUS

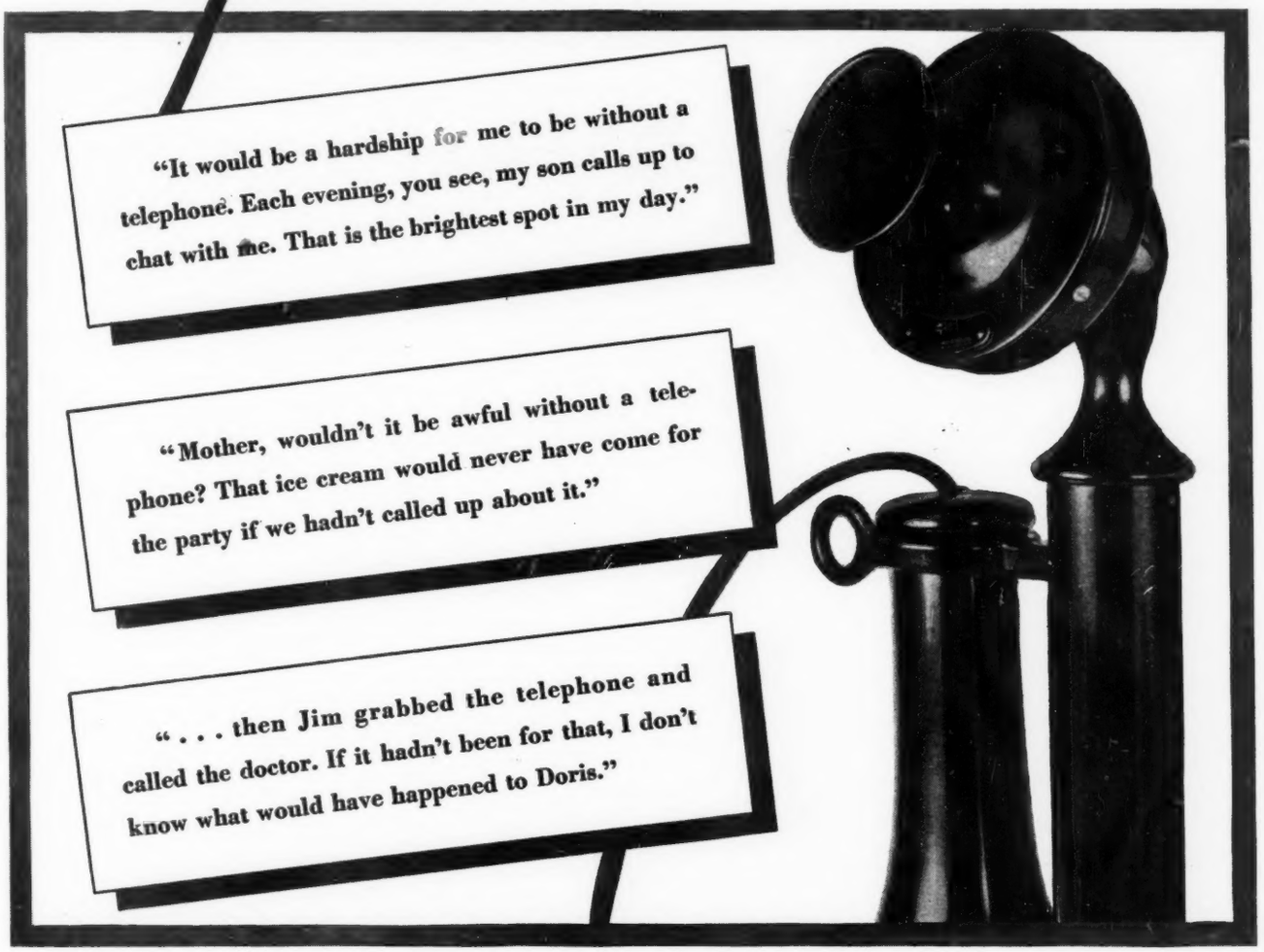
E. G. Stroud, Member A.S.M.E., President The Cleveland Engineering Agency Co., 219 Huron-Ninth Building, Cleveland, Ohio, has for 30 years been engaged in technical placement work. Employers wishing to engage Executives, Engineers, Designers, Draftsmen or other technical men are invited to use this service. Applicants available should write for blank and list of opportunities.

SALARIED POSITIONS
$2,500 to $25,000

This thoroughly organized advertising service of 24 years' recognized standing and reputation carries on preliminary negotiations for positions of the caliber indicated, through a procedure individualized to each client's personal requirements. Several weeks are required to negotiate and each individual must finance the moderate cost of his own campaign. Retaining fee protected by a refund provision as stipulated in our agreement. Identity is covered and, if employed, present position protected. If you have actually earned over $2,500, send only name and address for details. R. W. Bixby, Inc., 115 Delward Building, Buffalo, N. Y.

It will pay you to watch the announcements on this page for an opportunity that you may be looking for or one that may be of interest to you.

A *Friend* in the house


"It would be a hardship for me to be without a telephone. Each evening, you see, my son calls up to chat with me. That is the brightest spot in my day."
"Mother, wouldn't it be awful without a telephone? That ice cream would never have come for the party if we hadn't called up about it."
". . . then Jim grabbed the telephone and called the doctor. If it hadn't been for that, I don't know what would have happened to Doris."

THERE are many fine things in life that we take almost for granted. Health, water, sunlight, green fields, loyal friends, a home to live in. . . . Not until some mischance deprives us of these priceless possessions do we learn to esteem them at their true value.

It is in much the same manner that most people regard the telephone. Millions of men and women have never known what it is to be without one. Each day, each week, each year, they use it freely, casually, as a matter of course.

The telephone has won an important place for itself in life and living because of service rendered. To keep friend in constant touch with friend, to help manage a household smoothly and efficiently, to give larger scope and opportunity to business of every kind, to protect loved ones in time of unexpected danger . . . this is the task of the telephone.

It stands ever ready to serve you — to carry your voice and your words to any one of millions of other telephones in this country or in foreign lands. You are in touch with everything and everybody when you have a telephone.

AMERICAN TELEPHONE AND TELEGRAPH COMPANY

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Advertising Forms of MECHANICAL ENGINEERING close on the sixth of the month preceding date of issue.

Space reservation for advertisements to appear in the January issue should reach us not later than Dec. 6th, copy and cuts by Dec. 10th.

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Coit Road & Kirby Ave., Cleveland, Ohio
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Lynchburg Foundry Co. 20
Lynchburg, Va.
Marlin-Rockwell Corp'n. ..... *3rd Cover*
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Morris Machine Works. ..... —
Baldwinsville, N. Y.
*National Meter Co. 18
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Never-Slip Safety Clamp Co. ..... —
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*New Departure Mfg. Co. ..... —
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*Pennsylvania Pump & Compressor Co. ..... —
Easton, Pa.
*Philadelphia Gear Works. ..... —
Richmond & Tioga Streets, Philadelphia, Pa.
*Republic Flow Meters Co. 17
2232 Diversey Parkway, Chicago, Ill.
*Robertson, John, Co. (Inc.) 14
121 Water Street, Brooklyn, N. Y.
*S K F Industries (Inc.) 19
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*Scaife, Wm. B., & Sons Co. ..... —
Oakmont, Pa.
*Shakeproof Lock Washer Co. 4
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*Shepard Niles Crane & Hoist Corp'n. —
370 Schuyler Ave., Montour Falls, N. Y.
*Simplex Valve & Meter Co. 14
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Smooth-On Mfg. Co. 4
570 Communipaw Ave., Jersey City, N. J.
Socony-Vacuum Corp'n. ..... —
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*Springfield Boiler Co ..... —
Springfield, Ill.
*Squires, C. E., Co. 8
E. 40th St. & Kelley Ave., Cleveland, Ohio
Staynew Filter Co. ..... —
19 Leighton Ave., Rochester, N. Y.
*Superheater Company. 1
60 East 42nd Street, New York, N. Y.
Taber Pump Co. 8
292 Elm Street, Buffalo, N. Y.
Taylor Forge & Pipe Works. ..... —
P. O. Box 485, Chicago, Ill.
*Terry Steam Turbine Co. 27
Hartford, Conn.
*Timken Roller Bearing Co. ..... *4th Cover*
Canton, Ohio
Tube-Turns Incorporated. ..... —
1303 Shelby Street, Louisville, Ky.
Union Carbide and Carbon Corp'n. 5
205 East 42nd Street, New York, N. Y.
*Wickes Boiler Co. 8
Saginaw, Mich.
*Yarnall-Waring Co. ..... —
Norwood Street, Philadelphia, Pa.

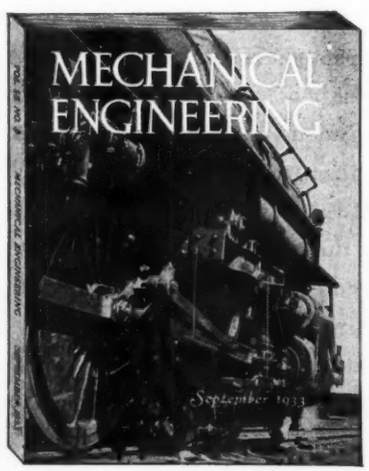
This list gives the names of display advertisers in MECHANICAL ENGINEERING during 1933 including this issue. Where page number is omitted after a name, it shows that the advertiser appeared in preceding issues. The asterisk (*) before a name indicates that catalog data of that firm appears in MECHANICAL CATALOG, 1933–34 edition.

Read by the VITAL Factors in Industrial Buying

THE broad scope of MECHANICAL ENGINEERING is evident from the articles which appear in each issue. Practically all feature articles come from prominent scientists, engineers, and industrial economists . . . and because of this, MECHANICAL ENGINEERING does a job that is not duplicated by any other publication.

It is a far-reaching job, from engineering and industrial standpoints, and consequently offers a means of effectively reaching industry at large (and the actual buyers and specifiers of industrial apparatus) in a very economical manner.

Apparatus and materials advertised in MECHANICAL ENGINEERING are exposed to the men who have the ability, through training and experience, to evaluate them intelligently. It will, therefore, pay your firm to give serious consideration to its consistent use for promoting the sale of their products.



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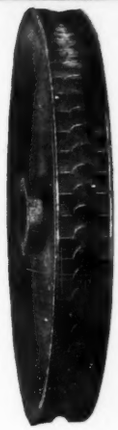
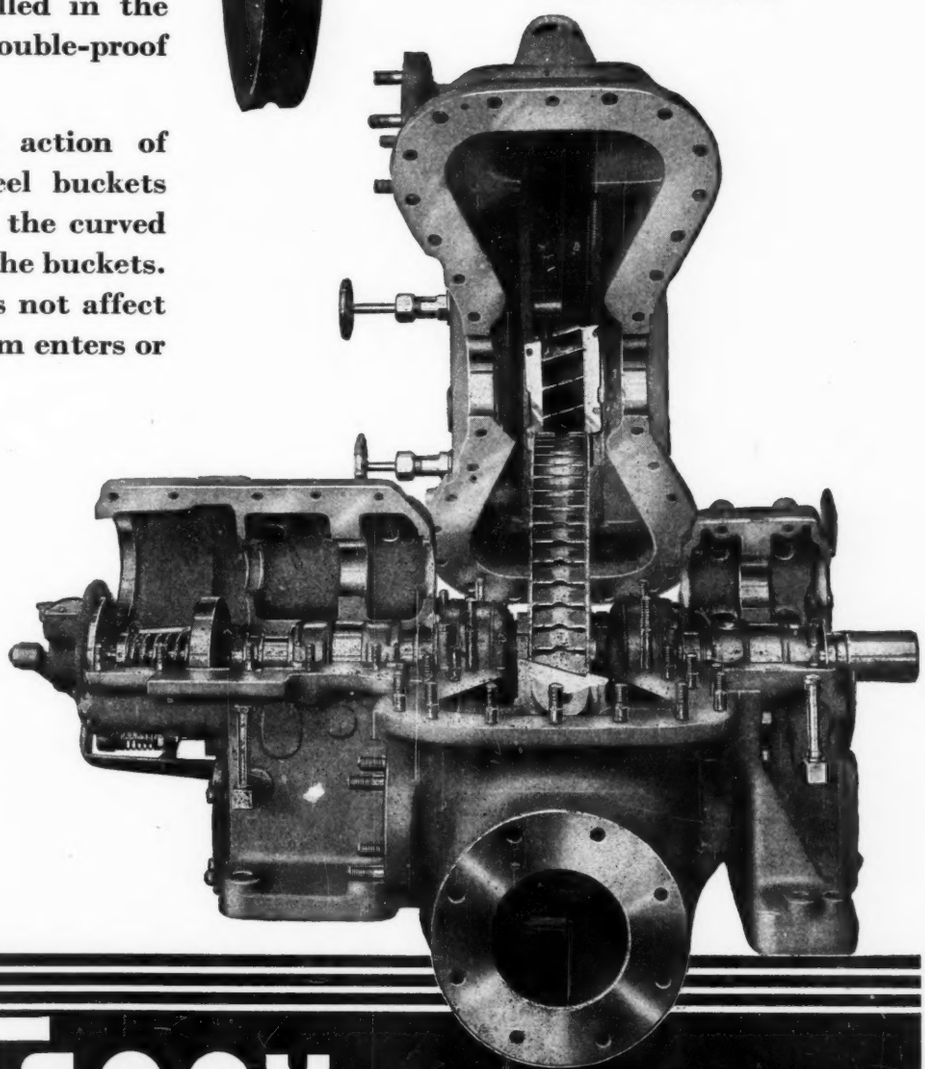


The Terry TROUBLE-PROOF Wheel

The Terry wheel, made from solid steel with buckets milled in the edge, is as simple and trouble-proof as a wheel could be.

The power producing action of the steam in the wheel buckets takes place entirely on the curved surfaces at the back of the buckets. Wear at this point does not affect the angle at which steam enters or leaves the wheel.

Therefore, Terry wheel turbines will maintain their original capacity for years. Ask for descriptive leaflets.



T-1090

The TERRY Steam Turbine Co.

TERRY SQUARE, HARTFORD CONNECTICUT

TURBINES GEARS SHAFT COUPLINGS

KELLOGG EQUIPMENT
is inherently reliable

The company that contracts for Kellogg equipment is purchasing not only engineering, material and workmanship, but also responsibility as to the performance of the equipment.

The operating records of Kellogg equipment, fabricated during the last quarter of a century, are the best evidence that The M. W. Kellogg Company is qualified to produce satisfactory installations.

THE M. W. KELLOGG COMPANY

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KELLOGG

Pressure vessels "Masterweld" for the Power, Refinery and Chemical Industries. Power plant and Industrial piping. Radial Brick Chimneys, Plastic Refractories. Cross, Holmes-Manley, deFlorez and Tube and Tank cracking units, absorption plants and pipe stills.

Leadership

There is always one bearing—in size and type—which will give you the best and most economical service under specified conditions.

Where can you find the particular bearing type that will fulfill all specifications for each requirement? M-R-C answers this question by offering a wide choice of the best types, which include many original designs developed especially by M-R-C engineers to handle the most difficult bearing problems of machine and equipment manufacturers.

With such a complete line from which to choose and with M-R-C engineering service to help you. it is a simple matter to secure the right bearing for every application.

The MRC-GURNEY Duplex is an original M-R-C design and one of 23 bearing types available in the M-R-C line. It is particularly adapted to heavy radial, thrust and combined loads. Where extreme rigidity is required, it can be pre-loaded.

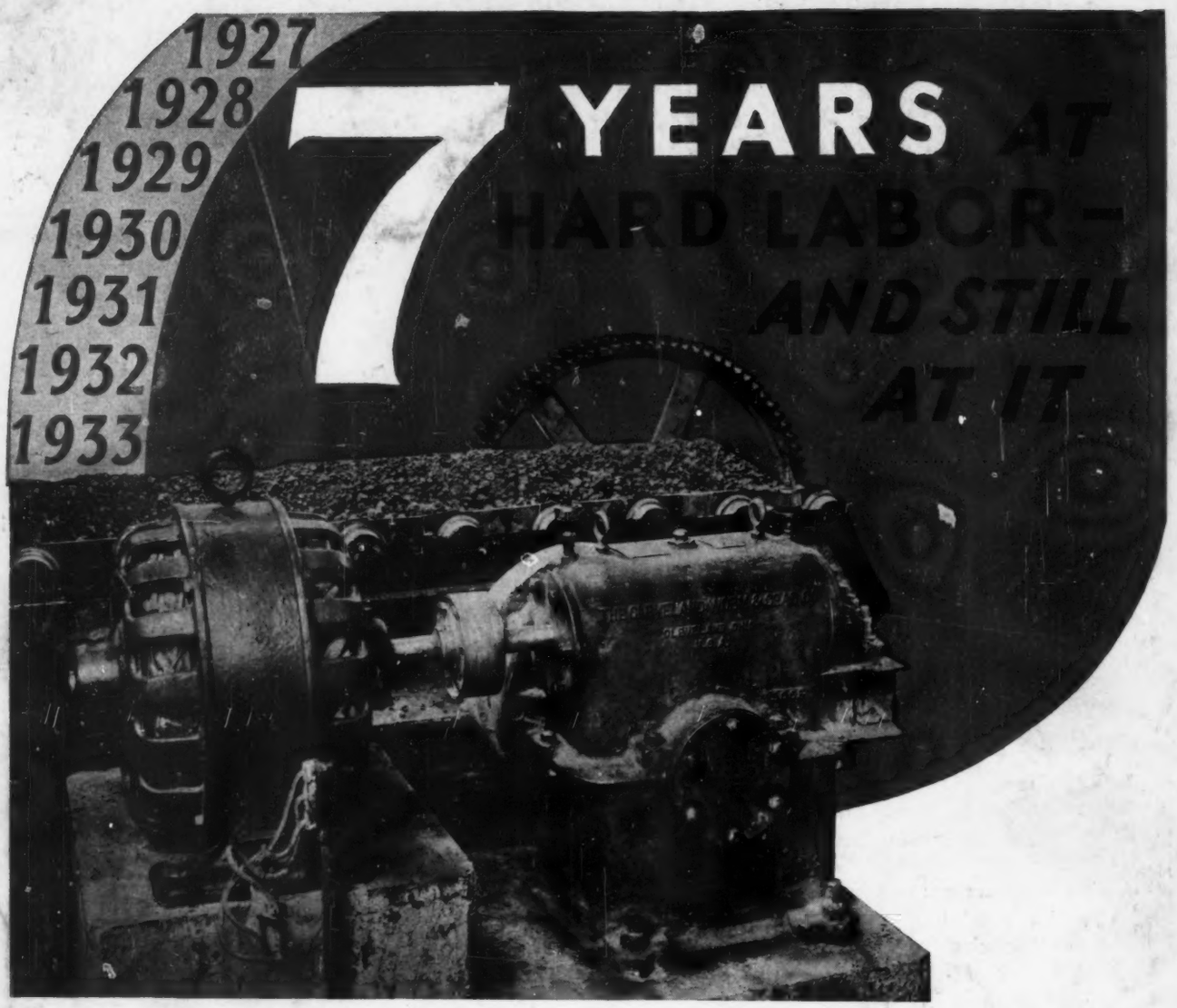
MARLIN-ROCKWELL CORPORATION

Executive Offices: [illegible], N. Y.

Factories at Jamestown, N. Y., Plainville, Conn. Chicago, Ill.

M-R-C STROM SRB BALL BEARINGS

• GURNEY • SRB • STROM • BALL BEARINGS •



This Timken Bearing Equipped "Cleveland" Speed Reducer is serving a life sentence in the plant of the Phoenix Portland Cement Company, Nazareth, Pa., and judging by the first seven years it is going to be a long life!

The reducer is used to run an apron conveyor. It has a ratio of 20½ to 1, and operates at 680 R.P.M.

The manufacturers, the Cleveland Worm and Gear Company, Cleveland, Ohio, say that as far as they know the Timken Tapered Roller Bearings in this unit have not required attention since it was placed in service in February 1926.

Another tribute to the dependability and endurance of the exclusive combination of Timken tapered construction, Timken positively aligned rolls and Timken alloy steel.

THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO

TIMKEN *Tapered Roller* **BEARINGS**